THE GLORY OF GOD IS INTELLIGENCE

REAT BASIN NATURALIST MEMOIRS

ber 3 Brigham Young University 1979

The Endangered Species: A Symposium

GREAT BASIN NATURALIST MEMOIRS

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The Endangered Species: A Symposium

No. 3 Brigham Young University, Provo, Utah 1979

INTRODUCTORY REMARKS[1]

Joseph R. Murphy[2]

As this symposium commences, it is appropriate to ask what motivated the conveners to choose this particular time to address yet again a now-familiar subject. More to the point, what specific aspects of the endangered species problem might be confronted in the framework of another symposium? At least three kinds of rationale for such a meeting come to mind.

First, the endangered species program in the United States, if not throughout the world, stands at a crossroads in terms of public and legislative support. Recent newsworthy events, wherein an endangered animal or plant is seemingly pitted against the agencies of human progress and welfare, have focused attention on what appear to be "either-or" alternatives regarding the species in question as opposed to some real or imagined public good; the Tellicoe Dam incident exemplifies this kind of dilemma. One result of this is that industry representatives, and often government agency personnel, live in constant fear that some obscure and hitherto undescribed species of clam or lousewort will forestall a multimillion dollar development. Politicians, at both local and national levels, frequently exacerbate the situation; short on biology and long on demagoguery, they attempt to undermine the basic concern of the public for the welfare of endangered or threatened species. Overzealous conservationists may further complicate matters by adopting inflexible and unrealistic positions. These polarized opinions leave little common ground for effective compromise. It is to be hoped that this symposium can contribute, in at least a small way, to some resolution of these tensions.

A second rationale for the symposium may be found in the fact that the invited participants, as well as those who have come to listen, represent a broad spectrum of agencies and organizations involved in endangered species concerns. Among those present are resource management personnel from numerous state and federal agencies, representatives from public and private utilities and other industries, university researchers, and spokesmen for private conservation organizations. This diversity of viewpoint and experience should promote a broad examination of the various issues, and perhaps a greater tolerance for the views of the "opposition." Too often, conferences on endangered species involve groups with identical or similar

[1]The symposium convened in the Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah, 7–8 December 1978.

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philosophical positions; this gives participants an excellent chance to reinforce one another's views, but little or no opportunity to gain new insights.

Third, this particular symposium differs from many held in the past by virtue of its emphasis upon several taxa of the humbler and less spectacular creatures, e.g. plants, insects, and other invertebrates. The public image of endangered species is probably embodied in or symbolized by such "glamour" forms as the peregrine falcon or blue whale. Though strong public support for these species is necessary and important, it is misleading and undesirable to focus all attention on them alone. Biologists realize that the condition of the so-called "matrix" species of plants and invertebrates often supplies a more accurate indication of the overall health of an ecosystem than does the plight of one or a few species of top consumers. Hence the status of these lower forms becomes a matter of priority for all of us, and not just for the erudite specialist. In a very real sense, then, this symposium seeks to break new ground in placing appropriate emphasis upon many species which have heretofore been neglected.

Obviously, the foregoing are not the only valid reasons for convening this series of meetings. There is still a genuine need to examine the fundamental philosophical premises underlying the management of endangered species. That there yet remain substantial areas of disagreement concerning the status of protected organisms was made manifest in the recent congressional debates directed toward making significant changes in the Endangered Species Act itself. In seeking these modifications, congressmen claimed to be responding to a "grass roots" demand for relaxation of standards promoted by a vocal segment of industry representatives and the public, who contend they have been economically disadvantaged by decisions such as that regarding the snail darter and the Tellicoe Dam. The long-term consequences of any substantial amendments to the present act will be closely monitored by those on both sides of controversies involving endangered species.

Broadening the concern for vanishing species to a worldwide scope, we find that there is increasing global concern for the perpetuation of threatened plants and wildlife, as pressures brought against natural ecosystems by expanding human populations inexorably mount. This subject will be treated in great detail by several of the invited speakers, and I only wish to point out here that, while there is much cause for pessimism, there are a few hopeful signs as well. At the risk of exposing my own biases regarding the relative worth of threatened wildlife, I will cite a few positive examples from the realm of avian conservation, an area in which I have some first-hand experience.

Certain species of raptors have responded favorably to the voluntary or enforced decline in the use of persistent pesticides, formerly a major source of environmental contamination. Noteworthy in this regard is the apparent recovery of breeding populations of the peregrine falcon in the United Kingdom and parts of northern Europe. A similar pattern of recovery has been detected among many populations of the osprey in the United States and elsewhere. It is to be hoped that this encouraging trend can continue, and that hard pesticides will be replaced by new-generation chemicals in those areas of the world where these problems still exist. In the battle to save the peregrine, additional successes have been achieved through the release of captive-bred birds into areas from which the species has been extirpated in recent decades. Results have been sufficiently encouraging to stimulate the drafting of plans for a similar effort on behalf of the seriously endangered California condor; another such program is contemplated for the Philippine eagle, a victim of the all-too-familiar story of destruction of forest habitat to meet the needs of a rapidly growing human population.

The kinds of success obtained with raptors can certainly be expected in the intensive management of other species of birds and threatened wildlife in general. For example, the International Crane Foundation of Baraboo, Wisconsin, has underway an ambitious program of captive breeding and restocking which has as its objective the perpetuation of each of the endangered species of that group. Some additional optimism in respect to the whooping crane has been engendered by a scheme to produce more young whoopers for

later release into the wild by cross-fostering of eggs and nestlings, using sandhill cranes as surrogate parents.

There is another category of species whose decline may have been arrested by increased public awareness and more enlightened management practices of wild populations. Such would appear to be the case with the golden eagle in the western United States. While direct and indirect persecution still account for considerable mortality throughout the West, there is good evidence that breeding populations are healthy and stable at the present time. There are also indications that at least many of these eagles adjust well or become habituated to various types of human disturbance, and are not as sensitive or inclined to abandon nests as many of us had previously thought. This in turn suggests that not all of our direst predictions need come true in every case, although it is obvious that many endangered species are not as adaptable and versatile as we would want. Another plus for the future of the golden eagle is that a long-awaited federal management plan for this species appears to be forthcoming. This plan is intended to offer management guidelines that will address problems of eagle depredation as well as deal realistically with the survival of the species. It is hoped its principal function will be to keep the golden eagle at a healthy distance from the endangered species list; to the extent that it is successful, it could serve as a model for the management of many other species.

In closing, I am tempted to deliver a stirring peroration in which I would remind you of the necessity for coming to grips with the issues at this critical time in the history of the conservation movement, of our custodial responsibility toward the subhuman species with which we share the planet, and of the challenge to initiate innovative and effective solutions. Instead, I will merely quote some rather straightforward if somewhat trite words ascribed to the late King George VI, which were adopted as the motto of the Timbavati Nature Reserve in South Africa:

> The wildlife of today is not ours to dispose of as we please. We have it in trust. We must account for it to those who come after.

Perhaps it is this intrinsic kind of value that we should always have before us in our deliberations on even the least spectacular of the endangered species.

THE EPOCH OF BIOTIC IMPOVERISHMENT

Thomas E. Lovejoy[1]

ABSTRACT.— 1978 was the first year in the history of man that legal power to eradicate a species was established. It is one of a number of signs of rapidly accelerating rates of extinction which may result in reduction of biological diversity by one-seventh to one-fifth, with a parallel reduction in the planet's capacity to support man and a permanent reduction in the potential body of biological knowledge. Species loss of such a degree would warrant designating the close of the Recent epoch and the opening of a new one of Biotic Impoverishment. A great deal of the extinctions will occur in the tropical forest areas of the globe but with possible environmental effects extending into the temperate regions. It will fall to science to help slow the rate of extinction, to decide on which species and ecosystems to concentrate conservation efforts, and to communicate the importance of biological diversity to government and society.

It is an encouraging sign for conservation that during this first week of December 1978, both this symposium and the first meeting of private conservation organizations in Central America are taking place. It is interesting that the latter is occurring in Guatemala, a country which honors the Quetzal, a trogon of extraordinary beauty, in three ways: as its national bird, as its monetary unit, and with a statue in Guatemala City. At the same time the travel route many of us followed here takes us through Salt Lake City, where stands one of the few other statues in honor of a bird: the gull which rescued the Mormons from orthopteran plagues, and the specific identity of which is probably lost forever in history.

But 1978 will also be remembered as the year when, for the first time in the history of civilization, the power to exterminate a species other than a pathogen was legally established. This certainly was not arrived at in any particularly intelligent manner, and its full meaning in the history of the biological degradation of the planet was and is appreciated by few: it is the first indication in the body of law that we are not going to save, or try to save, the full array of species in the biota, and raises the terrifying questions of which and how many species will be written off. The new Endangered Species Legislation takes a step toward answering those questions by according lower-class status to the faunal majority represented by the invertebrates, as opposed to those lucky enough to have spinal columns.

At first, species will wink out one by one like city lights as night deepens, but soon there will be a rushing torrent of extinction. This year also saw all but the last remnant of natural forest on Bali cut over, leaving little natural habitat for the Rothschild's Mynah, which fortunately does thrive in zoos. As far as I know, nobody has answered the question of how many extinctions the Bali forest destruction represents. It carries special meaning when we reflect on how much was learned about how the world works when Alfred Russell Wallace crossed the narrow strait between Bali and Lombok and began to conceive of the science of zoogeography and, later, of natural selection. He grasped natural selection independently of Darwin, yet so effectively that he propelled Darwin into publishing the volume which so greatly changed man's view of his place in nature. It is indeed likely that some of the recent extinctions on Bali were of species actually described by Wallace, a sad tribute to a man who did so much to advance knowledge.

One little-appreciated aspect of the recent and forthcoming extinctions is the implication for the future growth of knowledge (Lovejoy 1978). An extinct species is one

[1]World Wildlife Fund, 1601 Connecticut Avenue, NW, Washington, D.C. 20009.

about which we can learn little, either in terms of its specific biology or role in nature, except what can be gleaned from the sad remnants of information held by museum specimens—remnants which are nonetheless valuable and deserving of more appreciation. Many species will, in fact, disappear without even a mention of their existence in the chronicles of science.

While there certainly is some knowledge to be gained from the response of biological systems to destructive manipulation, it remains negligible when compared to what can be learned from living biological systems over the long time available when species continue to exist. Indeed one might think of human knowledge, whether in general or about biology in particular, as a growing n-dimensional hypervolume, with a volume Ve at any point in time. Whether there is a total potential body of knowledge is probably a question for lengthy discussion, but for the moment and for the sake of argument, let us assume that there is such a definable body, and that it can be represented by another hypervolume, Vp, which contains, and is many orders of magnitude larger than, Ve (Fig. 1).

Until relatively recent times, it can be said that throughout human history society has striven to enlarge Ve, deriving considerable benefit from doing so, and essentially driving Ve to approach Vp. The effects of the relatively small number of man-generated extinctions up to this moment have been minor, but now, as we enter the epoch of Biotic Impoverishment, which probably deserves to be treated as an epoch distinct from the Recent, we are allowing Vp to shrink and to approach Ve. Yet, as living organisms, surely we must realize that biology is the most important branch of knowledge for human welfare.

Most of us, even endangered species biologists, tend to underestimate the extent of the impoverishment of the biota that may lie before us. Here in the United States, already a highly developed nation with a human population now predicted to peak at a mere 253 million, it is possible to entertain the notion that we can have our fauna and flora and the sybaritic pleasures of the consumer society as well. There are occasional problems with endangered species and public works projects in conflict, but it seems possible to at least dream about having both.

But such is certainly not the case in the tropical forest countries of the world, which are, with a couple of exceptions, all lesser-developed nations eager to ape our ways. The FAO estimate that tropical forest destruction currently occurs at 50 acres a minute is truly terrifying. These forests are a biological treasury, and the conflicts between traditional development projects and endangered species are many orders of magnitude greater than in temperate regions. I recently had the

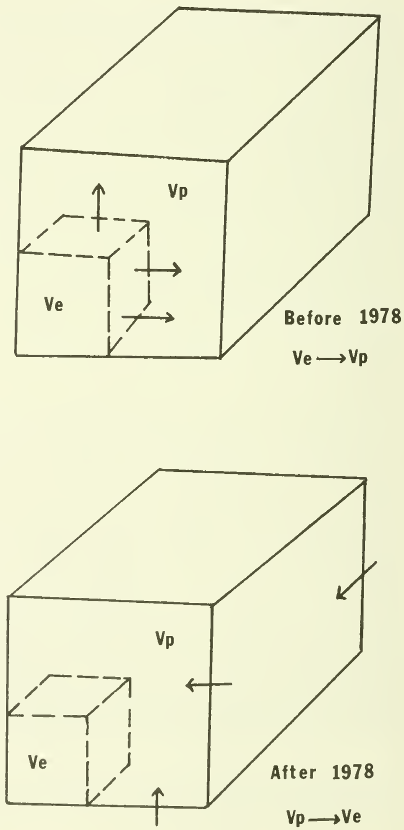

Fig. 1. The relationship of expected (Ve) and potential (Vp) knowledge.

difficult task of producing for a presidential study an estimate of extinctions that will take place between now and the end of the century. Attempting to be conservative wherever possible, I still came up with a reduction of global diversity between one-seventh and one-fifth, principally because of what will happen to tropical forests. No doubt some of my colleagues think I am mad, but I would challenge them to produce a better estimate. If my estimate turns out to be too high it will either be because society has made considerable changes in its ways, or because it will take a bit longer to reach the same reduction in diversity. The U.S. example to the international community will be very important.

The problem of biotic impoverishment then is considerably greater than can be appreciated from an overview of endangered species here in the United States. Our American collection of endangered flora and fauna really represents but part of the forward contingent of a great rush to extinction. This all raises many questions for science and society, including the most terrible one of all, one which few are brave or foolhardy enough to ask: namely, can we continue to treat the value of a human life as a constant whatever the number of people may be? I am enormously uncomfortable even asking it, let alone trying to answer it, yet, even if ignored, it will in part be answered by the degraded capacity of the planet to support man if biotic impoverishment proceeds apace.

It is more comfortable to try and answer the scientific and technical questions raised by biotic impoverishment and it is these that this symposium is largely addressing. Certainly science has a critical role to play in efforts to reverse the tide, and it needs to be recognized that such science is as intellectually respectable and as useful to society as, for example, laboratory work on DNA hybridization.

In many cases it is a race with time. World Wildlife Fund is launching a major research program on the problem of the minimum critical size of ecosystems, or why and how ecosystems set aside in the midst of landscapes converted to man's purposes shed or lose species. How much more desirable it would be to have the results in hand now, because most opportunities to set aside a representative series of the planet's ecosystems will occur in the next two decades. Yet we have to make do with the situation.

It is important that universities and agencies recognize that conservation is an appropriate activity to which biologists should devote some of their time. Indeed it is probably correct to say that today a biologist can make as much of a contribution to science by helping to save species and ecosystems, and, therefore, future opportunities to study biology, as by more traditional scholarly pursuits.

To science should fall the terrible questions about which species and ecosystems to save and which not to save. Which of us would be comfortable about saying one species is more important than another? Yet it is clear that all will not be saved, and that it is preferable for scientists to address those questions rather than deferring to the less knowledgeable. Certainly we would be wise to try and avoid having to make such decisions in unthoughtful haste—but maybe the awful nature of the questions will drive us that much harder to keep the number of such decisions small.

There is another critical role for science, namely articulating the true meaning of biotic impoverishment for society. Too often both scientists and society in general focus on the individual species rather than on the recognition that the impoverishment of the biota represents a reduction of the planet's capacity to support man. Just on the basis of destroyed coastal wetlands it can be said that the fundamental capacity of the planet to support man is less today than a century ago. This erosion of our biological wealth has been masked by the constantly refined abilities of technology. Technology has fostered the illusion that we can get more and more from less and less, a dream that soon will be shattered; the cracks are already appearing.

Scientists must articulate the true meaning of endangered species as indicators of stressed ecosystems and as yet another sign of erosion of the basic quality of life. When the Devil's Hole pupfish was being endangered by a lowered water table, the real question was about the rights to reduce that natural resource base. It is not always easy to deduce the complete meaning for society of any particular endangered species, but it will always

be generally true that it will reflect deterioration of a biological system. When arguing the case, we cannot always expect the exploiters to play fair; poor human behavior with respect to questions of dwindling resources is all too familiar.

Our society is generally ignorant of the importance of biological resources and hence of endangered species. One Supreme Court judge harbored the view during the case of the Tellico Dam and the snail darter that the Endangered Species Act meant endangered species might be found behind already existing dams and it would be necessary to run around letting the water out. And a distinguished senator was concerned most of his state might be declared critical habitat for the grizzly bear; perhaps he was worried about their votes? It is really up to all of us to employ all our energies and intellects to correcting this dangerous state of ignorance. We should clearly make the case, for example, that dwindling biological resources are making a major contribution to problems of economic inflation.

Society worldwide has been rocked in recent weeks as the story of the charnal millefeuille of Jonestown emerged layer by layer in the media. How many of us recognize that we are well into the beginnings of a biological Jonestown? As in Jonestown, there will be human survivors once the epoch of biotic impoverishment passes. But their existence will be forever an impoverished and degraded one. The question of how degraded and how impoverished lies before science and society.

ACKNOWLEDGMENTS

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QUESTIONS TO MR. LOVEJOY

Q. It would be interesting to have a figure on that one-sixth of the species lost you have computed.

A. You mean in terms of numbers of species? If the total biota for the planet is estimated at lying somewhere between 3 million and 10 million species, which gives you some idea of how ignorant we are about the biology of the planet, and if one takes the more conservative figure of 3 million, the loss is on the order of 500,000 to 600,000. The actual homework I went through to arrive at all of that is going to be published in the *Global 2000 Study*, which was requested by President Carter more than a year ago in his environmental address of 1977 and will emerge sometime in the coming September. That particular section will certainly stand out because a lot of the reviewers of that study who are not biologists and not particularly aware of what's happening in the tropical regions found it very difficult to believe and so it may be the only portion of that study with a name actually attached as an author.

Q. Would you explain your statement about fauna without vertebrae having less of a status in nature than vertebrates?

A. Well it's true. When it comes to invertebrates the secretary of interior has the ability to exempt certain public works projects from the Endangered Species Act without taking it through the long process to ultimately what some of us call the "Extinction Squad" setup in the new legislation. It really doesn't say flat out that the secretary of interior can allow a nonvertebrate to go extinct, but it says that he need not recognize discrete populations. Maybe some of the Department of the Interior people can explain it a little more fully than I, but there was a clear distinction drawn between the two.

Q. What are the strategies to address the problem of the destruction of tropical rainforests?

A. As currently treated, tropical rain forests are generally regarded as one-time use resources to be cleared and replaced by something else. That something else is often not economically viable in the long term. It's really a matter of proving that there are in fact considerably more gains from protecting as much of the tropical rain forests as we can than from converting them to short-time use.

Q. The recent modification of the Endangered Species Act was supported around the country. Some of the major conservation groups supported that modification. Now I understand that the World Wildlife Fund also supported the modification and I'd like to know if that's correct or what your position is.

A. During the period when the new endangered species legislation was being considered in recent months, some conservation organizations supported the modification. Was World Wildlife Fund one of these? It was not. The problem was that the biological reality and the political reality simply did not coincide. It is very clear, particularly from the Senate vote, which I think was something on the order of 94 in favor of modification, that there was little sympathy within the Congress for maintaining the Endangered Species Act as originally laid out. We, in fact, World Wildlife Fund and some other organizations, worked quietly behind the scenes to try and get as strong successor legislation as we could possibly get, but we simply were not about to go on record and condone anything that might lead to extinction. I think this was well understood by the staff of the Senate subcommittee in question.

Q. I have two comments to what you had to say today. First of all, forgive me if I have trouble thinking about tropical rain forests today. I deal in the area of management, which is where most of the problems

are being solved, at least in this country. If we set ourselves as biologists aside and say it's us against them, then two things may happen. First, we may become like a federal agency that I know of that says we have this pristine untouched piece of land and we're going to keep it pristine and untouched by allowing 10,000 people in and then it's going to stay somehow miraculously pristine and untouched. Second, which is more likely, the "other side" will win because they have more influence and more people. I think that we need to concentrate more heavily on the interface between the scientific community and the people and, in a democratic country, I think that is more appropriate.

A. I don't have any difficulty with that at all. In fact, I think in a sense that's what I was trying to say by saying we have to articulate what it all really means. But it's all in the best interests of all of us to be worrying about what is essentially the proper biological management, not only of the United States, but of the entire planet and that naturally falls into two distinct parts. One is making sure that you protect all the pieces—all the biological pieces—with a series of representative ecosystems properly designed so that they can be managed to protect their integrity, and I might add that it's getting harder and harder to protect an ecosystem anywhere without management of some sort. The other part is making the rest of the face of the planet biologically productive in a sustainable fashion and in a fashion that will in no way threaten the sort of species bank you've set aside. For example, we at World Wildlife Fund are taking a long shot at trying to talk to the last of the American billionaires, Daniel Ludwig, who has an operation in the Amazon about the size of Connecticut where he has cleared forest and is growing trees for pulp and rice. If I actually do get a chance to have a reasonable discussion with him, my point to him is not going to be that he shouldn't be doing what he's doing, because it is probably more intelligent than most of what's being done in the Amazon, but rather that the long-term security of his own operation depends on protecting the ecological integrity of the Amazon as a whole.

Q. You alluded to a correlation between biotic impoverishment and economic inflation. Would you care to elaborate on that subject?

A. Probably, if one searched around, examples could be found. For instance, the price of fish is increasing as the supply dwindles and the demand stays high. I only began to think about this ten days ago, but certainly this process has to be occurring here and there. The problem is to sort it out from the incredible maze of vectors that comprise economics and really demonstrate what's happening—and that's part of the problem.

Q. Mammoth is now about $5 a pound. The summer Chinook is in very great danger; we might have to drain Grand Coulee Dam to save it. In one of your other statements, you said that we have to protect habitats that have been damaged or destroyed and renew them. No summer Chinook were caught this year, except for about 1,500 by the Indians. At one time there were billions of pounds of Chinook. Crab is now about $5 a pound.

A. I'm really delighted to have that example, Well, in fact, if you probably start thinking about it, the price of lobsters and other marine products has certainly risen a great deal in recent years and that may be one of the more clear-cut situations. The world fisheries peaked about 1970. They made a slight recovery this year, I believe, but all along there has been an increasing catch effort, an increasing amount of actual fossil fuel energy going into the pursuit of these fish, and certainly the demand for them has been increasing, too.

Q. Are there any calculations on how much of a decrease we are going to get in atmospheric oxygen if these tropical forests are destroyed?

A. The problem of tropical forests with respect to oxygen turns out to be no real issue. They, in fact, consume about as much oxygen as they produce. The real problem in terms of biogeochemical cycles may well lie in the carbon which is stored in tropical rain forests. Tropical rain forests represent the largest terrestrially stored pool of carbon, and it was estimated as long ago as 1954 by Evelyn Hutchinson that the increase in carbon dioxide in the atmosphere probably came equally from the burning of fossil fuels and the destruction of forests. The whole problem of global circulation of carbon and where the sinks are certainly isn't a clear matter, but we do know that CO_2 is increasing and that if we destroy two-thirds of the tropical forest (which is the estimate by 2000) we will release an enormous amount of carbon into the atmosphere. The question is how rapidly the natural sinks can absorb it and bring it back to normal level. If there is a pulse of carbon in the atmosphere, then we may get into problems of climatic change, change in rainfall regimens, and temperatures in the temperate zones. The tropical rain forests really aren't all that far away.

Q. It seems like we're expanding on the strategy of the common ideal. How can we deal with individual countries that are bent on destroying a habitat which may affect the rest of us?

A. If I had the answer to that I might be head of the U.N. There is no easy answer to it at the moment. Many, such as Roland Clement or I, work on a country-by-country basis. I endeavor to persuade the Brazilians, for example, that proper management of the Amazon is in their best interests as well as that of the rest of the world in terms of, say, carbon. On the other hand, there is increasing recognition within governments, even in Latin America, which people were despairing about for so long, that there are major problems. There is now an Amazonian pact among all the Amazonian nations which, at least in rhetoric, talks about proper management of the Amazon. There are some interesting questions involved in that. Take the example of the contributions of biological species to modern medicine, especially the importance of a primate species. Take a cure that comes from one of those species and it is very rapidly distributed around the world as an international resource, so we may be approaching the time when some biological resources, at least, are

recognized by the international community as being international resources, and pressure will therefore fall on some of the less well-behaved countries to clean up their act.

Q. Are people as much a problem as governments?

A. Oh, it certainly is both. Roland Clement is going to address problems of people.

Q. Is corruption ever a problem?

A. Well, corruption is a problem. I would guess that at least in Latin America, which is my major "beat," ignorance is a greater problem than corruption.

Q. Do you think there really is a middle ground between biotic deprivation and the goals of preservation of the biota?

A. I think there has to be. It's just a matter of how much we want to let it hurt before we really respond to it. I think it's as simple as that.

Q. What about the review board set up under the new endangered species legislation to make decisions on seemingly irresolvable conflict between endangered species and public works projects? How busy will they be, and how eager will they be to exercise that power?

A. We're really talking about a play of attitude and how that will affect the whole process. The Endangered Species Act up to the point where it was revised certainly involved thousands of cases of seeming conflict that were all resolvable at staff-level discussion with the Department of the Interior. The single exception was the Tellico Dam and snail darter, and that really became an exception only because the TVA was completely recalcitrant and refused to acknowledge that it was subject to the law. If one reflects on those figures, it might say that only rarely will the Extinction Squad have a nasty decision to make. If, on the other hand, agencies feel that the creation of the Extinction Squad has weakened the power of the Department of the Interior, they may feel less need to be pliable in discussion and they may get very busy up on top. I don't think they're going to be happy to do this at all. My own particular solution to the whole thing is to erect a large black marble slab on the mall in Washington so that we can engrave on it the name of the species exterminated and the names of the members of the squad at that time.

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CULTURE AND SPECIES ENDANGERMENT

Roland C. Clement[1]

Abstract.— Species endangerment has so far been addressed mostly by biologists. It is now important to involve social scientists, inasmuch as the problems are man caused. The history of our attitudes, our uses of the land, and the reasons wherefore are problems for everyone.

The evidence suggests that the causes of endangerment may be grouped under (1) direct and indirect exploitation of resources, and (2) population displacement by modern agriculture, with consequent migration to the city or to the forest frontier, where accelerated forest destruction is the result. The displaced people are part of the marginalized two-thirds of the human race and will destroy what is left of nature in order to survive unless we help them become self-sufficient.

Such a refocusing of Western civilization, which has so far been parasitic on nature and a marginalized humanity, will require a new world view by the dominant one-third of us, perhaps based on Whiteheadean philosophy, wherein we accept a participatory role in a complex of processes that evolve from one another.

The focus of this paper is an attempt to broaden perspectives on contemporary species endangerment. The biology that is currently being elucidated by a spate of discussions of this problem is fascinating and helpful, but not enough in itself.

Let us first summarize very quickly the two principal causes of man-caused endangerment under two categories of pressure: exploitation and competitive exclusion. These are well known, but we tend to generalize them too much. For example, there is abundant and growing objection to *direct* exploitation, such as whaling, sealing, even hunting, and more recently against economic development which destroys key habitats. But we still neglect the impact of the killer-buyer relationship in the exploitation of wild species, partly because it is diffuse and largely illegal, and therefore difficult to quantify. It is also a more recent phenomenon. The new traffic in animals and their parts we need to confront and regulate is a by-product of the jet age and the mass-consumption society. It is a result of uneducated affluence.

There is cause to believe that the United States alone generates a $10 million annual traffic in live birds; that two to four times the number of individuals delivered perish en route; and that "products" made from wild animals involve sales which are several times $10 million. The Justice Department is now attempting to assess this traffic more accurately, almost for the first time.

There is also a need to study the implications of the sheer weight of human numbers on management policy. Numbers probably now mitigate against the rational management of our wildlife resources. What we recently considered "moderate use" now adds up to excessive demand and exploitation.

It is the same with competitive exclusion. We stress human population growth and tend to point the finger at the poor who still favor large famlies. But we have neglected the socially disruptive displacement of people by agricultural "modernization." Thirty years ago, the growth of capital-intensive and technology-intensive mechanization in U.S. agriculture sent 10 million blacks to the cities, and today the Green Revolution or some less spectacular form of agricultural modernization is doing the same thing to world peasantry. The only way to call this modernization progressive is to overlook the social and ecological disruptions for which it continues to be responsible.

The displaced people are flooding the cities and rapidly destroying their viability because the cities are incapable of assimilating such numbers. Or the people become modern-day colonists along the frontiers of

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the remaining forest, destroying it at a catastrophic rate.

Having been slow to understand the social dynamics of labor displacement by machines and gasoline, we have misidentified the impact of marginalized human groups. We blame what seem to us insensitive attitudes toward forest destruction by these people, or we point to over-population as a basic cause. We must learn to recognize that today's forest destruction is a by-product of our own economic demands. It was to facilitate mining activities by foreign capital that Brazil's trans-Amazon highway network was built; and it is to satisfy America's hamburger culture that cattlemen have displaced corn farmers from nearly half of Central America.

Another neglected element of competitive exclusion which needs to be seen as a senseless ecological pressure is that of the mechanized mobility of this generation. This is exhilarating, but it allows one species to disrupt the existence of all other species as never before. Its unfavorable effects are another result of uneducated affluence. This effect may, of course, be constrained within a decade or so by the energy shortage.

At a La Jolla seminar on endangered species, Lovejoy (1978) outlined the scientific needs of late twentieth-century conservation. He called for species research to identify minimum habitat requirements, for island biogeography-type studies to identify species maintenance needs as against individual needs, and for ecosystem research. Lovejoy also called for a new conservation anthropology focused on the study of human attitudes and values, but leaving out the needs of the Third World, important as he knew these to be. He asked that this new field of study inquire into the biology of our own species, so that we may learn what has led us to take such an adversary stance toward the environment.

As already suggested, much as I would value more biological knowledge of ourselves and other species, this will not suffice to reduce the rate of extermination which is now underway. We need a conservation anthropology but it must be a much broader inquiry than attitudinal research; it must investigate our world view, which is the way people "characteristically look outward upon the universe." This calls for an investigation of our culture, because culture is the sum of our ideas about ourselves, our environment, and the social institutions we have devised to get things done.

Anthropologists (Hall 1977) tell us that we cannot understand our own culture by self-examination or introspection, but only by comparing the approaches of other cultures. Other cultures furnish us a necessary point of reference. Therefore, rather than the psychologist, it is the historian, studying older cultures, and the anthropologist and the geographer, systematically studying existing cultures, who are our best guides to understanding ourselves and our neighbors. They can help us unravel the social psychoses that cause us to undermine our own existence through internecine struggles and the impoverishment of the biosphere. How ironic that we have heretofore been so heedless of the survival of other cultures. We need one another, if only for dead-reckoning purposes! Will it turn out to be the same with those other nations, the wild species?

Our own culture, a variant of Western civilization, is now old enough to be viewed somewhat objectively by mature historians. Ordinary citizens cannot yet do this because they have internalized culture and are not yet scholarly enough. But they can be taught. Two of the most intriguing historians of our day who may serve as models and teachers are Fernand Braudel (1978), the Frenchman who is the authority on the growth of civilization in the Mediterranean basin, and Immanuel Wallerstein (1974), who is engaged on a three-volume study of the modern world system which is our economic system.

The particular importance of Wallerstein for our theme is that he has disaggregated the modern world system. We are all familiar with the fact that the nations of the world normally include one or a few dominants, but Wallerstein is convincing in demonstrating that this is an interdependent system, wherein a small group of core nations systematically exploit a larger group of peripheral nations. The danger is that the core nations build up such a high life-style by exploiting the peripheral nations that they become dependent on this unbalanced system of exchanges. It is noteworthy that it is this sub-

sidized well-being that allows the core nations to enjoy the internal political freedom they boast about and mistakenly see as the *cause* of their well-being instead of a by-product. The peripheral nations, conversely, must impose some form of coerced labor to extract the raw materials for export, while consumption at home is constrained. Economic development for the core nations is maintained by underdevelopment of the peripheral nations. This is a large part of the Third World problem.

History also teaches that dominance in this system is a shifting phenomenon. Spain was the first leader, but for less than a century. The British enjoyed dominance for a very long time, but lost it to the United States during World War II. There are many signs that the dominance of the United States may not be longer lived than Spain's unless we become more appreciative of the relationships involved and modify the system to remove its worst inequities.

In any event, because the most worrisome threats of extinction are focused in the world's tropical regions, and these areas are all peripheral nations in the world economic system, it is obvious that we must look to the exploitive life-styles of the core nations if we are to introduce a more rational balance between numbers of people, their material demands, and the carrying capacity of the regions involved. It is the mass-consumption society that has the most "give" in it. A first task in this monumental transition may be to analyze and display those ecologically senseless agencies in our culture that have provided the compulsive drive to exploit the planet as though it were a midden heap. People must be shown that their culture has become counterproductive before they can be expected to make the necessary changes.

In addressing the particular problems of the Neotropics, we will benefit from Brazilian anthropologist Darcy Ribeiro's (1971) analysis of our Western Hemisphere system. The cultural complexity of the hemisphere is highlighted by Ribeiro's need to recognize three categories of people. First are the Witness People, the descendants of earlier native civilizations that were crushed by the Spanish invaders. These are the Aztecs of Mexico, the Maya of Guatemala and environs, and the Incas of Peru and Bolivia. These people comprise a large but marginalized component of the modern-day populations of their new countries. A second group is that of the New People, where the European colonists amalgamated lesser tribes, including imported African slaves, and thereby created a new mixed human stock. Such an amalgam is characteristic of Brazil in particular, and of Venezuela, Colombia, Chile, the Antilles, southern Central America, and the southern United States.

Finally, there are two groups of Transplanted People, New World Europeans so-to-speak, who simply pushed native peoples aside on first conquering their areas. These are the Anglo-Americans of Canada and the United States; and the River Plate people of Argentina, Uruguay, and Paraguay. Notice that these two groups occupy the temperate zones of our hemisphere. We are still, in many respects, a bunch of tribes, but we are tied together by an economic system whose exploitiveness has become unbearable for two-thirds of the world population newly enlightened about their true status by American movies, radio, and television.

Let me be more specific by calling attention to recent studies of what is happening in Central America. In what is unfortunately a somewhat obscure publication for many of us, Berkeley geographer James J. Parsons (1976) reported that the expansion of artificial pastures in Central America at the expense of both cropland and natural forest is a regional phenomenon with drastic, overlooked consequences. In most of this region in the 15 years prior to Parson's report, the area in planted pasture (mostly in African grasses) and the number of beef cattle had nearly doubled. But the per-capita consumption of beef in those same countries had actually declined, because most of this production was for export. This expansion of cattle raising was done at the expense of the Indians and mestizos who formerly raised corn for themselves on these marginal lands. Dispossessed by the cattlemen, these people have either migrated to the cities or have gone to the forest frontier to engage in shifting cultivation by cutting the forest. Within a few years, of course, the colonists find it necessary to abandon their plots and to cut new

forest, mostly because weeds become more expensive to fight than cutting forest. The cattleman then moves in behind them, rents the abandoned acreage for a pittance, and plants it to grass. The peasants have not only been dispossessed, but they have become a free labor supply for cutting the forest.

Although lauded as progressive and modernizing by local and national governments and by international agencies like AID and FAO, it is this system of land use which has become the chief cause of tropical forest destruction in the neotropics. It is, of course, also impoverishing already marginalized human populations. We have all known for years that the pressure of so-called land squatters, with machetes and fire, were a serious threat to any forest preserve in Latin America, but Parsons and a few young anthropologists were the first to show that this destruction is the end product of a widespread economic system anchored in the hamburger culture of the United States. The U.S. link has not yet been spelled out in detail, but it seems obvious. The dire effects of this extensive land use shift of the last 20 years or so on the Indians of Chiapas are now being documented by Robert Wasserstrom (1977, 1978), James D. Nations (1979), and their colleagues who worked, until recently, as the Centro de Investigaciones Ecologicas del Sureste (CIES) in San Cristobal de Las Casas.

It is time to suggest that the environmental awareness that has come to so many in this decade of the seventies is akin to a religious revelation. Having become aware that our economic system is parasitic on both nature and people, we are now challenged to redesign our world view in line with a more consistent vision of the joint realities of our lives: the environmental, which is the substrate of our existence; and the social, which is a measure of our humanity in making intelligent, perhaps even enobling use of our opportunities. This calls for a reassessment of our science and technology, our values, and even our unstated, unexamined theological assumptions, since willy-nilly, we have some vague concept of the destiny of mankind. Obviously it must be a joint venture, and it will take time, but each of us can help by engaging in some fraction of the task and by involving others.

We are likely to discover in that process of review that the principal assumptions of our Western civilization—homocentricity, rationality, technocracy, and progress—have become an embarrassing myth. We have idolized our own creations instead of simply appreciating them as events in our history as developing organisms. Having demythologized nature and his origins, modern man himself now stands in need of demythologizing!

Ecology has taught us that we are involved in systems within systems, and that we both impact and are impacted by these systems. But scientific reductionism, useful though it may be as methodology, has become a dangerous, unwitting philosophy. It seems likely that a great deal of that sense of relationship to the environment which we lack, but which the ancients had, is due to the specialism and incrementalism encouraged by reductionism. This has, of course, also affected our educational approaches and made for a hasty emphasis on specialization for the sake of preparing practitioners. Education should involve helping people see whole systems before training them to analyze and manipulate the elements of these systems.

However, to invent a new outlook is not to destroy the old, but to give it a new form, a new emphasis, a new reach. Jay Forrester (1978), who prepared the way for the Limits to Growth debate, has now suggested that we have perhaps already been through the technological age. This does not mean that we are through with technology, but that the age which is dawning will not be awed by technology and will use it in the service of all men instead of as an end in itself and for a relative few.

It seems obvious that, if we are to save the million or so species we fear may be lost along with the destruction of the tropical forests of the world, we must open our system of inventive production to that two-thirds of the human race which was marginalized during the mad rush for domination. The marginalized people will otherwise be forced to chew up the forest in a frantic effort to survive.

But the earth cannot support its present overload of humans at a standard of living we

would like. The first step must therefore be to eliminate waste in order to make our resources satisfy more people; then to tailor our demands to more modest proportions; and finally to adjust our numbers to a new sustained yield economy instead of the present liquidation of resources that passes for production. Done in stepwise fashion, we will be pleased to see that efficiency and frugality do not hurt.

We can draw inspiration from the process philosophy of A. N. Whitehead (1933) of a half century ago, and from the new interest in the implications of historical consciousness. Whitehead's cosmology is summarized in the thesis that "the ultimate and fundamental reality of the universe is a multiple and never ending complex of processes developing out of one another." This is both a scientific and a metaphysical statement of fact. To think in process terms is to acknowledge our dependence on the systems that produce us and our responsibility to contribute, insofar as we can, to the advancement of these processes instead of destroying them for temporary self-satisfaction. The way of historical consiousness (Stevenson 1969) is a restatement of the same concept: that when the reality of existence, and we ourselves, are understood as historical, we become aware of a responsibility to and for history. In both cases the appeal is not to morality as injunction, but to participation in a process.

The theologian Paul Tillich once said that the salvation of man and nature are one and the same task. More recently the anthropologist Edward T. Hall said that the population-environment crisis and the crisis of relationship to self must be solved together. It seems to me we have enough testimony to get started on the reconstruction of our culture.

POSTSCRIPT

A frequent response to the approach taken in this paper is that it is too optimistic, as though I expected things to right themselves as soon as awareness is more widespread. It is also objected that "education" takes too long.

But education is not restricted to that long sequence of school attendance we currently impose on our young. It may also affect those in control of our social systems, and, through them, all those in between. A culture does not change until all the people in it also change. There is no telling how long this will take, but a crisis or unusual leadership may make it happen rather suddenly.

The destructive portend of current practices has caused British astronomer Fred Hoyle (1977) to suggest that the salvation of the human race may depend on an early collapse of our economic system. He sees two likely options for a high-technology society like ours: (1) if an essentially unlimited source of energy were perfected *before* the human race agrees to limit its population and subsist by less destructive life styles, a collapse leading even to extinction is likely. If, on the other hand (2) an early economic collapse causes us to come to terms with ourselves, and we limit population everywhere, the consequent rebirth of invention, if it then provides ample energy supplies, may allow the human race to rise to new heights that are hardly imaginable at present.

QUESTIONS TO DR. CLEMENT

Q. How can we show people that their culture has become counterproductive and needs to be changed?

A. Let me first make the point that cultures don't change until almost everybody changes. It is an educational process, and scientists will need to help by pointing out the implications of what ecology is teaching us; that way we will revamp our educational system. If the people don't understand that they partake of larger systems, they will continue the short-sighted exploitation which has characterized our civilization. We always begin by accepting the cultural systems we are born into. And it was a great, exciting, and in one sense enlarging experience to be caught up in this wave of exploitation. But now the very system of exploitation is in question, so we must help people understand that we are not proposing a Marxist revolution but a revamping of our system before it breaks down. There are abundant signs that the breakdown is already underway.

Q. Will we succeed in revamping our civilization to prevent the extinctions you and Lovejoy are so concerned about?

A. Let me take a different tack. Education usually takes a generation, but it may come quickly if a crisis occurs and our leaders can point out new directions; the people may then turn around almost overnight. One reason I'm optimistic about the future is that our system is so close to its end that we will not achieve the growth projections in which the business world believes. We are already so deadended in so many areas that if we don't wake up to our problems

in a decade or so, we'll be squeezed down to size. It would take another lecture to develop this point, but the petroleum problem is a good clue. We have a naive faith that all we need do is invest more in production at home to get more energy. Of course we can do this, but only at increasing cost. Every million feet of new oil well costs more than it did yesterday, both in dollars sunk and in diminished return. And the more we pump, the quicker we will run out. This is what needs to be made obvious to the people. We currently buy the surpluses of the Middle East because these are the cheapest ones. Even American agriculture will have to be turned around because of the energy crisis.

Q. You talked about marginalized people in Latin America, but are there not marginalized people in the U.S. who will get caught in this crossfire?

A. There are many other marginalized people—the blacks, the hispanics, and the Amerindians at home, and the people of Asia and Africa. Reassimilating these people into the world economic system will not be done overnight, but if we at least accept this as a challenge and work at it, we will soften the impacts.

Q. What kind of progress is Canada making toward becoming a conservationist society?

A. I'm afraid they are not making much. The Canadians are making all the same mistakes in exploiting their energy resources that we have made. This is not surprising because Canadians are a marginalized people too; they are exploited by the United States.

Q. You spoke of the need to educate the public to the fact that our system has serious problems; you also said that we must convince people that they will need to get by on a smaller piece of the resource pie. How can you really expect this to work? Won't some economic penalty be necessary? People usually change when they see a personal payoff of some kind.

A. Well, yes, but you are opening up another area which cannot be addressed with a simple answer. There are no simple answers. In a democratic society we must seek to persuade rather than impose. But if time runs out we face a dilemma. Within a decade or so we will probably truly be in an energy crunch, and we will then learn that voluntary approaches to the conservation of energy are not enough; they put the good guys at the mercy of the cheaters. When that time comes, it is hoped someone will have the persuasive skills to put this over. If we don't accept this, we'll have to fight over it; and if we do that we're in real trouble.

Q. Isn't that happening now? This audience is aware of many of these problems, but we also have large corporations with lots of money advertising in national magazines and on television, saying: "Don't worry. Buy your gas dryers and gas stoves. We'll have gas for as long as we need it."

A. Exactly. We already have a conflict of approaches. A large section of the economic community actually still believes that resource "production" is simply a matter of investment. Look at the ads run by Mobil Corporation, "The Capitalist Revolution." They say, just get the government off our backs and everything will be all right. They seem ignorant of the fact that they are liquidating the resources. Of course, if you don't care about the future, that's another matter.

Q. Isn't it correct that increasing the price of, say, petroleum may not solve problems of exhaustion and inflation?

A. Yes, but price is important. If we can make people pay the full social costs of what they wish to do, they must then decide what they most wish to do instead of greedily trying to do everything, or consuming everything. If we have artificial price structures, the public is misled. Industry agrees with this view. The question is who will get the price increase? It should be a tax that we can use for constructive uses—in the case of energy, to rebuild a mass transit system where the people are.

Let me now add that I'm delighted at the response you provided because a large part of the answer to this big problem is people like you tackling questions energetically and in an open fashion. We must then try to involve more people in our tentative conclusions. If we don't, our troubles won't go away.

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PERSPECTIVE

John L. Spinks[1]

Abstract.— The fact that mankind has desecrated much of the natural world is recognized. The rate of plant and animal extinction has increased in North America from an estimated 3 species per century 3,000 years ago to an average of 143 per century since 1620. Endangered species protection began in the Fish and Wildlife Service in 1938 with the purpose of the Aransas National Wildlife Refuge for the whooping crane. A committee on rare and endangered species was formed in 1962 by the director of the Fish and Wildlife Service and a tentative list was published in 1964. The Endangered Species Acts of 1966, 1969, and 1973, together with subsequent amendments, provide the legislative authority for the present program. The intent of Congress, through this legislative authority, is to avoid irreversible or irretrievable commitments of resources by identifying problems of environmental impact projects early in the planning stage. Examples in the step-by-step development of the legislation and its operation were reviewed.

I certainly sympathize with the difficulty that Tom Lovejoy and Roland Clement had with their presentations prior to mine, but with all due respect I think perspectives are a bit difficult to address. Perspectives are very individualistic things held certainly very precious to those individuals who have them. When organizations or groups have a similar perspective on something, they're often institutionalized. I would not be so presumptive as to try to imply that the Fish and Wildlife Service collectively or myself individually has the only perspective on endangered species and endangered species programs. All we can do is hope that a general public interest and a realistic perspective can be gained by all of those who may affect or be affected by our administering the Endangered Species Act of 1973 as amended.

To have any perspective I think you must have a little historical sense as to how we got here from there. Then I want to get into the nitty-gritty things that are not so much perspective as they are pragmatic problems we're going to have in administering the 1978 amendments. We do not have all the answers to a number of rather weighty questions presented by those amendments, but I would like you to leave here today with at least as much knowledge as we have as to how we're going to proceed.

The fact that we have desecrated much of the natural world is almost given at this point. There have been various ways to quantify this. Nobody is sure what the quantification means. We are not exact in saying that it means a certain loss to us by having made a given species extinct. At least we do know what happened here in North America. In the 3,000-year period prior to our arrival, the natural extinction rate was about 3 species per 100 years. Since the Puritans arrived at Plymouth Rock in 1620, over 500 species and subspecies of North American flora and fauna have become extinct. Norman Myers expresses the impact we have had on resources, on species and subspecies in an excellent statement, condensing earth's existence down to one calendar year, as follows:

> To condense the evolution of life on earth into a more comprehensible frame of reference, suppose the whole history of the planet is contained within a single year. The conditions suitable for life did not develop until late June. The oldest known fossils are living creatures about mid-October and life is abundant for both animals and plants, mostly in the seas, by the end of that month. In mid-December dinosaurs and other reptiles dominate the scene. Mammals appear in large numbers only a little before Christmas. On New Year's Eve at about five minutes to midnight, man emerges. Of these five minutes of man's existence, recorded history represents about the time the clock takes to strike midnight.

The period since 1600 A.D., the one referenced earlier, when man-induced extinction began to increase rapidly, amounts to about three seconds. The quarter-century just begun, when the disappearance of species is put on the scale of all the mass extinctions of the

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past put together, will take one-sixth of a second. So the process by which species have become extinct has been incredibly accelerated by the impact of man.

We have classic cases here in North America, such as the passenger pigeon, which once numbered in the billions and became extinct in 1914. It is very difficult to say what the reaction of the people who lived in that time might have been as these species went by the boards. There were certainly some who were economically sensitive of the loss. Passenger pigeons made great feed for hogs. They could be caught on their roost and killed by the barrel loads with sticks, so there was some reaction, but it was not really a societal attempt, with money behind the movement, to do something about endangered species. It was not until the 1930s, when the 1932 Animal Damage Control Act was passed by Congress (which is still in the operative legislation, incidentally, for federal activities in animal damage control), that there was a hue and cry from the Society of Mammalogists about consequences to vulnerable species. Dr. E. Raymond Hall still remembers vividly his concern as a young man for what had happened to the gray wolf, and he did not like the future prospects.

The Fish and Wildlife Service really began "endangered species" protection, in terms of major fiscal outlays, in 1938 with the purchase of the Aransas National Wildlife Refuge for Whooping Cranes. The cranes at that time had reached a low of 14 birds and were in a very critical situation. The service continued to work on whooping cranes, and in 1956 a coordinating committee was established between the service and representatives of the National Audubon Society to see what could be done about a concentrated effort to save the whooping crane. Since then progress has moved steadily in terms of sensitivity and concern for vanishing animals, but I would emphasize that the early concern was more for animals and more specifically mammals and birds than any consideration of lesser lifeforms. If it had big brown eyes and was cuddly or in some way looked noble, then folks had an increased tendency to love it and be concerned if it was disappearing. Skuas and invertebrates really didn't turn folks on too much then and, as a matter of fact, they don't turn folks on very much now. That's another story.

In 1962, a committee on rare and endangered wildlife species, composed of the various divisions of the Fish and Wildlife Service, was formed by the director to begin wrestling with the problem of what should be done with these critters for which we should be responsible. By January 1964, a tentative list of endangered species was put together by the service and circulated for review, and this resulted in 1966 as "the red book," the good old red book you may have seen in your libraries on native, rare, and endangered species.

Perspectives. How did we get from the last passenger pigeon in 1914 to a federal action in the late 1960s? It's difficult to say. Endangered species are very difficult animals to think about and the legislation that protects them is a very difficult type of legislation to understand. I think one perspective that folks have on the Endangered Species Act reminds me of Mark Twain's comment on the Bible. He said that he didn't understand very much of it, but what he did understand scared the hell out of him. In many respects this is where we have been with endangered species legislation. The first Endangered Species Act of 1966 was a rather innocuous piece of legislation, in all honesty, and particularly so when compared to the 1973 act. It allowed us to list native, endangered species and to acquire land with Land and Water Conservation Fund monies. There was no procedural requirement as to how things were put on the list, however, and it didn't do a critter a lot of good because being listed afforded no protection from taking. It was, however, a first fledgling step to a meaningful national law protecting endangered species. Also, there was only one category, an endangered species, and an endangered species was basically a basket case, something that was in dire straits. Reference was made to rare species in the red books published in 1966 and 1968 but rare species were not included in legislation. In 1969, a second endangered species act was passed, The Endangered Species Conservation Act, and this act went a bit further than the 1966 act. It did broaden the definition of fish and wildlife to include mollusks and crustaceans, a rather

large step forward because, heretofore, predominant concern had been with vertebrates, mostly those that were lovable. The Lacey Act was amended to allow a broader degree of enforcement by including reptiles, amphibians, mollusks, and crustaceans. Foreign species could be listed for the first time under the 1969 act. A very important international step was taken by the 1969 act when the secretary of the interior was directed to seek the convening of an international ministerial meeting before 30 June 1971, at which would be concluded a binding international convention on the conservation of endangered species. That convention took place and is now the Convention on International Trade in Endangered Species or Wild Fauna and Flora, a very important international agreement to which some 46 countries are now parties. Then came the big one, the Endangered Species Act of 1973, which President Nixon signed into law on 28 December. The Endangered Species Act of 1973 could accurately be described as a "sleeper." I am sure Congress was unaware of the full implications of its provisions.

Tellico Dam is a good case in point. Tellico had been under litigation from local citizens who were opposed to it for a number of years before the snail darter swam into the picture. Perhaps Tellico and the snail darter could be likened to the whale who swallowed Jonah under inverse circumstances. Jonah swallowed the whale and the snail darter seems to have engulfed Tellico Dam. After the snail darter was scientifically described, an emergency rule making listed the species and determined its critical habitat. We were petitioned to do so.

The federal district court in which the case was first tried did not find for the plaintiffs. In addressing the issue of saving either Tellico Dam or the snail darter, they found for the Tennessee Valley Authority. The district court's decision was appealed. It was reversed in the federal appellant court and ultimately came before the U.S. Supreme Court. The Supreme Court also ruled for the snail darter but not in the true context of that statement, in that the Supreme Court said, "Yes, this is really what the Endangered Species Act says. This is what Section 7 of the Endangered Species Act says." It says that all federal agencies shall insure that actions authorized, funded, and carried out by them do not jeopardize the continued existence of a threatened or endangered species or adversely modify or destroy its critical habitat, and that's what the TVA's actions were clearly going to do. There was no question of that being the ultimate outcome should the dam be completed and the gates closed.

The ripple that reached tidal wave proportions following the decision could perhaps be characterized as the "Chicken Little Syndrome." Do you remember Chicken Little? Chicken Little was out in the barnyard one day when an acorn dropped on his head and he assumed the sky was falling. Other parties with similar federal works projects saw the acorn fall on Tennessee Valley Authority's head and assumed the sky was going to fall. It was Chicken Little all over again. There was a deep concern that economic progress, if you will, including many important public works projects, would be halted because of endangered or threatened species being present.

We felt in the Fish and Wildlife Service at that time, and we still do to this day, that the concern was an overconcern, that we could find no justification for it. The service had completed some 5,000 formal and informal consultations with other federal agencies. Three of those at that time had been litigated. In one instance involving the Indiana Bat and Merramac Park Lake, the court found in favor of the U.S. Army Corps of Engineers both at the district court level and the appellant court level. In the second case involving the Mississippi Sandhill Crane and Interstate 10, the court did find for the plaintiffs, but that highway has since been completed. The questionable interchange is going in. The conflict was resolved ultimately by the Fish and Wildlife Service and the Federal Highway Administration working cooperatively, so we could have our cake and eat it, too—or have our cranes and their interchange, too, if you want to put it like that. We felt there was a degree of overreaction to the problems that were going to be caused by Tellico. We thought it was an anomaly. It was not typical of what the Endangered Species Act was going to do in the future. Nevertheless, a number of individuals

were concerned about this, and a number of bills were put before Congress to address the problem. There were any number of variations on these bills, including specific exemptions for the Tellico Dam and for another TVA project on the Duck River. Some 14 or 15 bills were being considered by Congress, some introduced in the House of Representatives, some in the Senate.

The first thing that happened, in terms of action, was a Senate bill, cosponsored by Senator Culver of Iowa and Senator Baker from Tennessee. This bill presented a mechanism by which an appeal could be made and a project exempted from the Endangered Species Act. A focus was finally made in the House of Representatives on a bill reported out of Mr. Legget's subcommittee which had that provision as well as a preliminary review step by a review board. The outcome of all this was an amendment to the Endangered Species Act which passed Congress in the eleventh hour on 14 October, just before Congress was going to adjourn. Unfortunately, our appropriation authority to administer the Endangered Species Act had expired at midnight on 30 September. We were out of business for two weeks because we had no money to operate the program. The act itself remained in effect, the prohibitions of the act remained in effect, and our obligations to consult remained in effect. However, we had no money to do any of these things. President Carter signed that bill on 10 November at 10:00 p.m. That was the last day the president had to sign the bill before it was pocket vetoed. That made a total of 41 days that the Office of Endangered Species, indeed the endangered species program, was out of business.

We are now back in business. We're digging out and we're trying to understand the 1978 amendments to the Endangered Species Act. I want to go over these with you briefly. They are too complex to focus on in great detail. Again I would qualify an ultimate consideration of what these amendments say to the extent that, until we have a firm reading from our solicitor's office on some finer interpretations of the intent of Congress, we are going to be walking a tightrope blindfolded at times to try to administer these and keep the intent of Congress uppermost in our minds.

One of the more interesting happenings was a redefinition of critical habitat. There had been no definition of critical habitat in the original 1973 act. It was mentioned in Section 7 of that act and it was defined by regulation by the Fish and Wildlife Service in the Section 7 regulations. The new definition basically confines critical habitat to the geographical area in which a species presently occurs. It does make allowance for consideration of specific areas outside the geographical area where the species is found, but only if these areas are determined to be essential for conservation. What does *essential for conservation* mean? *Conservation* is defined in one place in the act, but we are not sure what the degree of *essential* is.

Another important happening was the definition of species. Tom Lovejoy alluded to the lessening of protection for invertebrates and, at one point, in one earlier bill which was not enacted, there was a rather glaring distinction made against invertebrates—as I recall, something to the effect that they could not have critical habitat determined for them. That was changed in the final act. The major difference made between invertebrates and vertebrates is that we cannot list invertebrates at the population level. They may only be listed at a subspecific level.

Now for Section 7 itself. The key elements for requiring an agency to consult with the Fish and Wildlife Service, if their activities may affect a listed species, are still in place. This has not changed at all. As a matter of fact, the necessity for consultation has been stengthened by these amendments because, without a good-faith consultation, an agency will not qualify for an exemption under other provisions of the act. There is more definition given to the opinion to be rendered by the secretary of the interior, i.e., the director of the Fish and Wildlife service to whom the authority to administer the act has been delegated. It now specifies what must be contained in the biological opinion.

An entirely new element called a biological assessment has been introduced which only applies to agency action for which no contract for construction has been entered

into and for which no construction has begun on the date of the amendments. A biological assessment must be done on projects that fall in this category. The agency that has the action must request from the secretary of the interior a list of proposed or listed species which may be found in the project area. The agency has 180 days in which to conclude a biological assessment to see what indeed is there. The intent of Congress is that you find out the problem in the early planning stage before you get in the middle of a dam and then end up with another confrontation on your hands. During this process and during the consultation process, the action agency cannot make an irreversible commitment of resources.

A federal agency, the governor of a state in which a project is located, or a license or permit applicant whose permit or license is being denied because of endangered or threatened species can appeal for exemption to an endangered species committee. The appellant has 90 days after a biological opinion has been rendered in which to submit this appeal. The endangered species committee is composed of seven members, the chairman of which is the secretary of the interior and the other members being secretaries of agriculture and the army, the chairman of the Council of Economic Advisors, the EPA, the administrator of NOAH, and one person or persons appointed by the president from the state(s) affected by the project action.

Before the committee gets to look at the exemption or the request for one, however, it is first referred to a review board, a second-tier process which was not included in the Baker-Culver amendment from the Senate. This review board has three persons on it, one appointed by the secretary of the interior not later than 15 days after the application, one appointed by the president, and an administrative law judge. It is the job of this review board to examine the application for exemption, and they look at four basic factors: (1) Does an unresolvable conflict exist? (2) Has the agency carried out the consultation in good faith? (3) Did it conduct the biological assessment required of it? (4) Did it refrain from making an irreversible commitment of resources?

Within 60 days after receiving the application for exemption, the review board must have been appointed and have positively determined that these criteria have been met. The board reports to the committee, and within 180 days after they make a determination they must recommend to the committee reasonable and prudent alternatives to the action, summarize the evidence as to whether or not the agency action is within the public interest and of national or local significance, and decide if mitigation and enhancement measures should be considered by the committee. Once the committee gets all this in hand it has 90 days to decide whether or not it will exempt a project from the requirements of Section 7. In the process of doing this, the committee must make four findings: that there are no reasonable or prudent alternatives to the agency action, that the benefits of the action clearly outweigh alternative courses consistent with preserving the species or its critical habitat, that such action is in the public interest, and that the action is of regional or national significance. However, after proceeding this far in the exemption process, if the secretary of the interior determines the exemption would cause the extinction of a species, he so advises the committee and the committee has 30 more days in which to decide whether or not the project will cause the extinction of a species by virtue of granting an exemption to the agency action. There is also a review provision by the secretary of state that if the exemption would violate any international treaty or obligation then the exemption cannot be allowed. This will be addressed in the regulations promulgated by the committee itself. They have 90 days after enactment of the 1978 amendments to propose these regulations.

This is the core of how the exemption process works, only the core. The complete, revised version of the act, with the 1978 amendments incorporated, will be available from the Fish and Wildlife Service sometime around 1 January. At the present time, we only have a copy of the signed bill itself and this can be rather confusing unless you are familiar with the 1973 act and can see where all the "wherefore's" and "thou art's" go.

One other thing that the amendments did was to provide for immediate consideration

of exemption for both Tellico Dam and Gray Rocks Dam. The committee has 30 days to begin consideration of both projects and 90 days to decide whether it will exempt. If it fails to act within 90 days, both projects are exempted by virtue of this statute.

There was an amendment to Section 6 of the act which for the first time brings plants under the purview of the grant-in-aid program. Heretofore Section 6 cooperative funds were only available for animals, not plants. Also, the bill authorized our expenditures under the act. I indicated earlier that we went out of business when our appropriation authority expired. We only received 18 months of reauthorization, which means we will go through the same process of having the act reauthorized in 18 months. We anticipate oversight hearings on the Endangered Species Act this spring, probably in both houses of Congress.

What we are going to do about getting on with listing of endangered and threatened species and determining critical habitat for these species is something else again. We had originally planned on some 200 rulemakings in fiscal year 1979. Our present estimate is that maybe 20 to 30 rulemakings will be possible. The reason for this is the greatly increased workload to list a species. It will be a more expensive process; it will be a more time-consuming process. Some of the elements involved in the new listing process are good: holding public hearings, notifying local people that an action is contemplated, publishing in a local newspaper. We think that the increased public involvement in the decision-making process will be beneficial in the long run.

We hope we can resolve some of the concerns that have been expressed over many proposals. It appears, however, that there are a couple of "Catch 22's" in terms of present proposals. There is a two-year expiration provision in the 1978 amendments. It says, in effect, that, if a species or critical habitat has been proposed for two years and it hasn't been finalized within that two-year period, it expires and must be withdrawn by the secretary of the interior. There is a one-year grace period, however, for existing proposals. That one year will be up on 10 November 1979. Over 1,700 plants are proposed. We realize we will be able to list perhaps a fraction of those. All of the existing critical habitat proposals will more than likely be withdrawn because of the new requirements involved in determining critical habitat. Those requirements include doing an economic analysis and an analysis of other relevant impacts and we're not sure what *other relevant impacts* really means. Here again the lawyer will come to our rescue.

We are going to place in priority form the existing proposals based on degree of threat before the on-year expiration period comes up. We do not have a large staff in the program. Basically the law charges us with the responsibility for the animal and plant kingdoms of the world. We have something less than 200 permanent full-time positions within the endangered species program split between the Office of Endangered Species, Federal Wildlife Permit Office, the Division of Law Enforcement, and the National Wildlife Refuge System. So the dilution of personnel across the program scope is tremendous. It is a challenge, a challenge which we welcome, and the espirit de corps within the program has never been higher.

Back to perspectives again. Perspectives are very difficult. At times it is difficult to justify, depending on the individual's perspective, listing a species and perhaps impeding a given project. The question keeps coming back. What good are endangered species or threatened species? Tell us in a very tangible fashion what good a snail darter is. We cannot answer that. We cannot give you a dollar and cent answer to that kind of question. The most lucid comment which addresses this concept, however, is one which was made by Aldo Leopold, who said that the first sign of intelligent tinkering is that you don't throw away any of the parts. With all of our sophistication, I think we are tinkering with phenomena that are much more sophisticated than we. Our concern is certainly for the survival of the species. It is also for the survival and well-being of mankind. It is our posture that, until our knowledge, as a race, as a society, evolves to the point that we can clearly know the consequences of our action by making a species extinct, it is very, very foolish to do so. It may be the part that we needed to make the clock run for another century or so.

Questions to Dr. Spinks

Q. Have I been given an impossible task then to provide for the Fish and Wildlife Service in Utah the data on 200 endangered species of Utah plants?

A. If you think we're going to do it next week, you'll be disappointed. If you think we're not going to do it at all, you're wrong. It's going to be a lot of jumping through hoops. We've had some other difficult hoops to jump through and our intent is to get this program unwound as rapidly as we can. We've been digging out from 41 days of inactivity, but I feel rather confident in telling you that your data is not going to be gathering dust for an indefinite period of time. If those species for which you are providing the information fall out as priority species having the most danger, the greatest degree of threat, they'll be among the first we get to.

Q. Is there any aspect of litigation involved in this new amendment? In other words, how do we give people the chance to question something we say is becoming extinct, like the snail darter? Does the applying agency have to provide research funds or try to relocate the snail darter even though they might not be successful in that aspect of threatened or endangered species?

A. Yes. The committee will actually direct the appealing agency as to what must be done on behalf of that species, and the agency taking the action is responsible for bearing the cost of that. Now in terms of construction projects, this cost is not considered in evaluating the cost-benefit ratio of the project. It will be an additional cost; but it would not, for instance, bring a project below parity and thereby make it unfeasible or illegal to build.

Q. In all the time limits that have been set, the 30 days, the 90 days, the 180 days, what happens if an agency or committee fails to meet these deadlines?

A. There is no slap on the wrist if anyone fails to meet the actual time frame. Some of those time frames, incidentally, are negotiable in that the 180-day biological assessment could be lengthened if the agency requested it with agreement between the agency and secretary. If you add up all the maximum time frames, however, including the 180 days, the total is something like 750 days that the entire process could take.

Q. But there is no traditional mechanism?

A. No, but the citizen suit provision of the act still applies, and anyone could litigate against any party that failed to meet its deadlines.

Q. It has been the thrust of the whole program all along that the brunt of the responsibility has fallen on other federal agencies, besides the Fish and Wildlife Service, and private organizations, too. But isn't it true in the West, where field work for proposed species is just starting? Now suddenly I'm being pushed. I know I'm speaking to you in a sense, but I'm also speaking to me. I'm one who elected the people who are passing these things, but 20 or 30 are not going to be enough. We need more people. There are a lot of areas where work needs to be done.

A. There is a "Catch 22" in everything, I guess. There's also a hiring freeze in the federal government at the moment which affects permanent, full-time positions. As a matter of fact, there is nothing we can do about that. I hope you can also appreciate the difficulty of bringing in a permanent part-time or some other less than permanent position and expecting that person to walk in and start doing something productive the next day. It takes a lot of expertise and training to write a decent rulemaking, for instance, one that will get by the scrutiny of the solicitors and be legally justifiable and adequate.

Q. All I'm asking is to just make an effort.

A. We are.

Q. Pertaining to the exemption process, other than litigation, where is the avenue for public involvement?

A. There is a provision which provides the meetings of both the review board and the committee to be open. It will depend on whether the committee decides to take testimony from the public. That point, I'm sure, will be addressed in regulation promulgated by the committee and by the review board. The final decision of the committee is subject to judicial review. It can be appealed to the courts, and there is specific provision in the legislation for that.

Q. When would you determine the rulemaking for critical habitat for the grizzly bear?

A. As I indicated earlier, it is very likely that all existing proposed rulemakings for critical habitat will be withdrawn. In effect, that proposed rulemaking would be invalidated and a reproposal would come forth. The reproposal would have to meet the new criteria of the 1978 amendments, including an economic impact analysis and identifying actions or activities within the area which might be affected by having the area designated as critical habitat—both federal actions as well as private actions. We do not have an economist on our staff and, quite frankly, it gives us some heartburn to consider a meaningful economic analysis. I am not being facetious when I say meaningful, because we're not going to try to short-cut the intent of Congress in this thing. They want an economic analysis, one that is meaningful, and that is what they are going to get from us. We don't know where the help is going to come from, perhaps from within the department and other agencies which do have economic expertise.

A. You recently listed some species in California without listing critical habitat. Are these being considered for withdrawal under new amendments?

A. No, anything that is already listed that did not have critical habitat determined at the time it was listed will remain a listed species. The amendments say that we may determine critical habitat for these species at some point in time. We can do this; we don't have to do it yesterday. What we do have to do in the future, however, unless it is prudent not to do so, is to propose critical habitat at the same time we propose listing of species, so these two things go along simultaneously. There was no provision for critical habitat in either the 1966 or 1969 acts. That is why we have a huge backlog of listed species that have no critical habitat.

Q. Isn't it true that any agency must consult the Fish and Wildlife Service before beginning any project?

Do we mean *any* project or are we defining projects?

A. No, when an agency identifies that its actions may affect listed species, that is when they must initiate consultation. It is the *may affect.* Now the confusing element here may have been my comments concerning construction contracts, projects for which no contracts have been let and for which no construction has begun. These are the ones that would have to do a biological assessment before things could proceed if there are listed or proposed species in the area, but that is different than consultation per se.

THE LAW AND ITS ECONOMIC IMPACT

Donald A. Spencer[1]

Abstract.— There is no adequate inventory of population size and distribution of most of the world's animal and plant species and lower taxa. Furthermore, populations are rarely static and continue to change in response to both natural and man-made factors. Thus clearance today for public works or industrial projects can be reversed tomorrow as new information becomes available. Lacking assurance that a project can be completed without new endangered species surfacing places an untenable constraint on the commitment of dollars for new long-term programs.

As a consequence of the absence of data, studies to determine occupied range, population levels, and habitat requirements of specific endangered species must be conducted on each project area. The direct costs of these studies are the responsibility of the project applicant. The time consumed results in project delays which can become a major expense item. Additional economic impacts are inherent in construction modifications and subsequent project operations intended to accommodate an endangered species.

Finally, the withdrawal of natural resouces to support endangered species can conceivably reach a point where the squeeze on other societal programs becomes unacceptable.

Thank you for making this time available to me. It's always a privilege to get together with a group that is intentionally interested in a good program and talk problems out.

I brought along this book. I thought some of you might want to obtain a copy of it. It is a proposed environmental impact statement on the effect of grazing on some of our western lands. This little book cost $250,000 to prepare. It is, actually, an excellent study; you'll be much impressed by what the authors and the various research teams have put together in it. But as I read through it and came to the areas of my own expertise, I found that, if we are going to consider endangered species on this 800-square-mile area this book is about, we're going to have to do the job. The information on endangered species, on wildlife and nongame species in general, is treated once over lightly.

In the back of the publication, I began to read the letters received about this program from people who actually lived on the area; and who were going to be affected by it, not an outsider like me who was reading what I considered to be a very excellent program. Then it occurred to me that this was just like what had been happening to me. You know most of my professional career has been spent in research in the field of animal biology. When you come up with a new tool or a new program or a new project that is the result of research and you're very proud of accomplishing something new for wildlife management, you send the report all over the country for trial. When it comes back to you from first one point then another, reviewers state that it won't work here or that it produces an adverse affect there. You're very bitter about it—you even tend to react violently. Then you begin to realize that of all the things research values most highly it is knowing the limitation of the new tool. Where are the boundary lines where it works most effectively? If you do not recognize those boundaries early, you are liable to lose the use of the tool in the areas where it would be valuable. There are literally hundreds of examples in the last four or five years to bear this out and I won't have to elaborate.

One thing we have to realize is that in asking for habitat for endangered species we are in competition, and I'm using that term advisedly, with a lot of other conservation objectives. For example, over 100 years ago we began a national park system that has grown to some 300 units encompassing in excess of 31 million acres. The Brown Pelican, which has been so much in the news of recent years, initiated the first unit of the National Wildlife Refuge System that has now grown to 34 million acres. We have now reserved between 100 and 150 million acres where wild-

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life receives top billing.

Building on these established programs, and adding such new ones as the Wild and Scenic Rivers (1968), National Sea and Lake Shores, Wilderness (1964), National Trails System, Marine Protection Research and Estuaries (1972), Research Natural Areas, Coastal Zone Management Act, Agriculture's Water Bank Program, Wetlands, etc., has become a veritible national obsession. Currently President Carter, under the authority of the Antiquities Act of 1906, has proclaimed 56 million acres in Alaska as national monuments, and the secretary of the interior has temporarily withdrawn an additional 54 million acres from any commercial development. The U.S. Forest Service has under review some 62 million acres of "roadless areas" for possible inclusion in the Wilderness System. The Bureau of Land Management, overseer of 470 million acres of public lands, is engaged in a similar "roadless area" review to determine what lands of theirs would qualify for wilderness designation.

In a very limited way, habitats purchased specifically to protect an endangered species add to the set-aside totals. But the greatest impact will result from "critical habitat" designations that, while not infringing on any use that does not adversely modify the habitat for a given endangered species, still impose costly constraints on change, to the point of completely preventing some projects useful to man. Alternate uses that are affected by critical habitat constraints can be quite varied, as the following from the U.S. Forest Service's *Wildlife Management Manual* illustrates:

> Many projects and practices authorized or carried out by the Forest Service are of such a nature that modification of the vegetation or land is often a direct or indirect result. These include activities such as recreation site development, land exchanges, timber sales, revegetation and reforestation, type conversions, water impoundments, road and trail construction, grazing by herbivores, and development that results in significant increases in the level of human activity in an area.

The patterns for establishing critical habitats give little assurance that very many areas will be free of constraints to protect one or more endangered plants or animals. A number of critical habitats, both established and proposed, are disturbingly large. The critical habitat for the Manatee includes every major estuary in peninsular Florida, sits astride the busy intercoastal waterway, and is one of the most intensively used recreational boat areas in the United States. The proposed critical habitat for the grizzly bear suggests 13 million acres in Montana, Idaho, and Wyoming which encompasses two national parks, Yellowstone and Glacier. Throughout the visitor season, a succession of trails, campgrounds, and back-country are closed to people because of bears. As for the Whooping Crane, a proposal will about triple its present 90,000-acre wintering ground and provide seventeen migratory stopovers in six states and a new nonhistorical experimental breeding range in three other states. Some of these brief stopover points are not necessarily small areas. Along the Platte River in Nebraska the linear 54 miles of bottom land totals about 103,000 acres; the proposed migratory stopover on the Niobrara River is 115,200 acres; the large proposed area along the Canadian border in northwest North Dakota probably exceeds 2 million acres. Then, surprisingly, it is proposed to include the dams and lake margins between maximum and minimum pool of the two largest flood control impoundments on the Missouri River (Lake Oahe and Lake Sakakawea).

As tne endangered list grows by the addition of relatively little-known species and subspecies from the enormously large pool of living plants and animals these resource set-asides can provoke a reaction that will damage even the best features of the program.

The Regulatory Thicket

The independent, consumer-owned power companies serving some 200 municipalities in eight Missouri Basin States found their present capacity for electric power desperately below what would be needed in the years just ahead. So they formed the Missouri Basin Power Project, which began constructing its first generating plant, the Leland Olds Station, in 1962. The construction required only *one* government permit and was completed in four years. Unit No. 2 at this site required *five* permits and went on line in 1975. Their next cooperative project, the Laramie River Station and Grayrocks Reservoir, got under construction in 1976 and has thus far re-

quired *43 permits and approvals* from federal, state, and local authorities. Their third project, the Antelope Valley Station, begun in June of this year (1978), has at this early stage required *69 federal, state, and local permits*—all of this within the experience of one vital cooperative project serving an eight-state area.

Like illustrations of the maze of government regulations are at every hand. For example, the atomic-powered electric plant under construction at Midland, Michigan, has acquired some *93 permits* to date.

The redundant nature of some of these regulations is a sad commentary on the efficiency that has marked so much of America's progress. Take, for example, the construction of a transmission line that links North Dakota and Minnesota. Not only did the federal Rural Electrification Agency require an Environmental Impact Statement (Study), but a Certification of Need had to be obtained from the Minnesota Energy Agency, a Certificate of Corridor Compatability from the Minnesota Environmental Quality Board, and two separate permits for Site Compatability and for Route Designation from the North Dakota Public Service Commission. The transmission corridor crossed four navigable rivers requiring four separate construction permits from the U.S. Corps of Engineers. It made eleven other water crossings, each requiring separate permits from the Minnesota Department of Natural Resources; crossed three wetland areas requiring as many easements from the U.S. Fish and Wildlife Service; made eleven highway crossings, each requiring a permit from the respective county highway department—which was in addition to two separate permits from the North Dakota Land Department, one labeled State Land Crossing, the other River Crossing; and crossed five different railroads requiring permits for each location. It can be agreed that such a corridor has to obtain easements across every privately owned parcel of land, so why should public land be different? The point to be made here is the large number of governmental agencies have replicated input into a single project.

A review of Sections 7 Consultation Logs of the U.S. Fish and Wildlife Service's six regional offices for the period of October 1977 through May 1978 reveals that between 30 and 35 different federal and state agencies contacted the Office of Endangered Species for advice on their responsibilities under the act.

With such a galaxy of regulatory agencies afield, there are few, if any, projects that do not require a permit or license of some kind. A western cattleman will need a grazing permit to use public land, a farmer will need a point source discharge permit for return irrigation flows, to build a dock or bulkhead on your waterfront property will require a permit, and, even if you wish to participate in the recovery of a Peregrine Falcon, thus enhancing this endangered species, you must have a permit. Regulation reaches into the most remote corner of our society.

The regulatory morass motivated President Carter in March 1978 to issue Executive Order 12044 "as a first step toward ensuring that regulations achieve their statutory goals in the most effective and balanced way." This now has been followed up by the Presidential appointment of a Regulatory Council

> to inform me, the public, and the Congress about the cumulative impact of regulation on the economy. The COUNCIL will help ensure that regulations are well coordinated, do not conflict, and do not impose excess burdens on particular sectors of the economy. The first report of this COUNCIL is to be made public no later than February 1, 1979.

At reoccurring intervals officials of the Office of Endangered Species have sought to clarify what is meant by critical habitat by saying that the act charges federal agencies—and only federal agencies—with carrying out provisions of Section 7. State and private actions not involving federal approval do not come under the act. This is meaningless comfort when it would be almost impossible to identify a private project that does not need some federal (or state) approval. Even if this were not so, Section 9 provides severe penalties for any person who "harasses, harms, pursues, hunts, shoots, wounds, kills, captures, collects, or attempts to engage in any such conduct" an endangered or threatened animal no matter where found. Thus the act, for all intents and purposes, affects public works and private projects alike.

The Permit: Often Elusive

The permit or license is elusive because it

can be withdrawn by the issuing agency on the basis of new information not previously considered, and because a court of law can order the permit suspended or withdrawn pending the outcome of a public interest suit which may rest only on some omission in the Environmental Impact Study. It can be disruptive because the regulation, or the factor requiring it, did not come into being until the project was partly completed.

Advancing technology has made most projects more complex to construct. Added safety and environment features, and the time-consuming efforts to comply with over-numerous regulations, all combine to lengthen construction time. Thus, to bring a major coal mine to full capacity, or a new power plant on line, can take ten years. Each year that passes sees a 10 percent increase in construction costs. With no assurance that a project can successfully negotiate the ever-changing maze of regulations, financing of projects that cannot be completed in a reasonably short time becomes quite a gamble.

The "biological opinion" resulting from a Sections 7 Consultation with the Office of Endangered Species is an agency approval (if granted)—in practice it has the force of a permit. A few examples will show that these biological opinions can exhibit every one of the above three deficiencies with respect to clearing the project for completion. Following completion of a broad Environmental Impact Study, the Bureau of Land Management received the following Section 7 biological opinion on a proposed phosphate mine on the Osceola National Forest in Northern Florida:

> It is my biological opinion, subject to the conditions identified herein, that the proposed project is not likely to jeopardize the continued existance of the endangered or threatened species listed above or result in the destruction or adverse modification of their critical habitats.

The conditions imposed are as follows:

> The Bureau of Land Management must reinitiate Section 7 Consultation should (1) new information reveal impacts of the above-listed species or their habitats which was not considered in this consultation, (2) the proposed leasing [be] subsequently modified, or (3) a new species [be] listed that may be affected by the proposed action.

The above clearance named only species on the established list. It did not mention that standing in the wings waiting to go on stage was a proposed list of plants and animals almost 10 times as long. Nor did it include Florida's official state list which names still other species. Lastly, on a project of this size, 52,000 acres, it should not be too difficult a task to come up with an undescribed species or one with very local distribution that has not yet been proposed for listing.

A well-known example of the late surfacing of an endangered species is provided by the Tellico Dam in Tennessee, where the small fish had not even been described as a distinct species of Darter until well after construction had begun.

More recently the Office of Endangered Species established a 54-mile stretch of the Platte River bottom in Nebraska as critical habitat for whooping cranes during migratory stopovers. Upstream some 275 miles was a power plant already under construction by the Missouri Basin Power Project. Extraordinary steps had been taken at the planning stage of this facility to have a conservation-acceptable project. Now, despite their holding all the required federal and state permits, their use of water from the Laramie River has been challenged in court because it might reduce by 4 percent the flow of water through the whooping crane's fall and spring stopover. This action threatens the $444,000,000 already invested in the project. Each lost day will cost $140,000 in interest on the money alone (or $50,000,000 a year).

Here, as in several other notable cases, the Endangered Species Act is being used to accomplish an entirely different objective. It is actually a matter of the continuing wrangle over water rights between the State of Nebraska, who initiated the court suit, and the State of Wyoming. Previously, the U.S. Supreme Court had awarded the water in the Laramie River to Wyoming, so there appeared to be no problem about the Grayrocks impoundment. What is incomprehensible to me is that midway between Grayrocks and the whooping crane's critical habitat is the Kingsley Dam in Nebraska that backs up Lake McConaughy, which is 20 times the size of the incompleted Grayrocks. The withdrawal of irrigation water at the Kingsley Dam must have marked

influence on the regulated flow in the Platte River.

The Informal Consultation

The Endangered Species Act of 1978, Section 7(c)(a) directs—

each Federal Agency shall . . . request of the Secretary information whether any species which is listed, or proposed to be listed, may be present in the area of such proposed action. If the Secretary advises . . . that such species may be present, such agency shall conduct a biological assessment for the purpose of identifying any endangered species which is likely to be affected by (the project).

It is analogous to being directed to a well for a drink, a well that hasn't been dug deep enough to strike more than a suggestion of water, then being drafted into the work force to dig the well deeper. Although the act suggests that this responsibility might be discharged in 180 days, a review of past directives from the Office of Endangered Species shows that such studies can take from a few months to several years, depending on the complexity of the biological assessment.

A number of federal agencies have elected to prepare in advance of requests for specific resource use, an Environmental Impact Study covering districts or broad subdivisions. For example, the BLM has programmed studies on 173,919,000 acres of public lands subject to grazing. The estimated budget to provide the 142 separate studies at current prices is $35,500,000, an average of $250,000 each. To date, 16 EIS have been completed, but the entire area will not have been covered until 1988. The proportion of this program that can be assigned to providing data on endangered species is usually quite minor. For example, a breakdown of an Environmental Impact Study for a proposed surface mining project in Wyoming, which cost a private company $500,000, shows the wildlife/vegetational fraction costing $190,000, with only $18,000 (or 3.6 percent) related to endangered species information.

Another example: The Departments of Transportation in the six lake states routinely asked for advice if they proposed repairing or replacing a bridge. In fact, in the period of October 1977, through May 1978, 20.9 percent of the entries on the consultation logs in U.S. Fish and Wildlife Service, Region No. 3, concerned bridges, and another 20.5 percent highway actions. Just as routinely they received the following informal "opinion":

Survey for endangered species or their habitat in the project area. (or) If through your investigations you find an endangered species or their habitat in the project area you should initiate a formal consultation.

In most instances involving bridges the interest was in one or more species of endangered freshwater mussels, which required the services of a qualified malacologist for underwater surveys and species identification. Aside from waiting for the proper season to do the work, these local studies could be completed rather quickly, as in the case of a contract to search 49,500 square feet of the Wabash River near Hutsonville, Illinois, at a cost of $2,500.

The Corps of Engineers, responsible for maintaining channel navigation in the upper Mississippi River, finds these same endangered freshwater mussel surveys far more costly and time consuming. They have awarded five research contracts totaling $263,977, four of which are now completed. A final report, *Freshwater Mussels of the Upper Mississippi River*, prepared for the corps by the Academy of Natural Sciences of Philadelphia, is a 400-page document. Please understand that this required study involved only freshwater mussels. Who is to say what other species and subspecies of freshwater invertebrates, fish, amphibians, or aquatic plants will require similar treatment in the future?

The magnitude of some of these studies to determine the impact of development projects on the environment is sobering. The Corps of Engineers has come under criticism for its dredging activities along our coasts and navigable rivers. Congress authorized a five-year thorough study of this program that has now cost $30,000,000. A part of that study is an eight-volume (1,502 pages) set of reports covering colonial bird use and plant succession on dredged material islands. Contracted to seven different teams of qualified ornithologists, these studies found that "62 percent of all colonial species (more than 156,000 adult birds) along the Texas coast in 1977 nested on dredged material islands." Included were the Least Tern, the Gull-billed Tern, the Roseate Spoonbill, the Reddish

Egret, and the Brown Pelican. In Florida, "approximately 50 percent of the colonial nesting sea and wading birds nest on dredged material and many more species use the islands for feeding and roosting."

What I gleaned from these studies was the exciting possibility of so locating and constructing these dredge-spoil areas as to create superior nesting habitat with minimal predation and disturbance pressure. But the decision between using the most cost-effective dredge disposal site and a wildlife-oriented one carries a price tag. For example, to avoid an endangered plant (Menzies Wallflower) the alternate to the most cost-effective disposal site for dredge spoil from Humboldt Harbor (California) is estimated to cost $150,000.

Some of the requests from the Office of Endangered Species for these preconsultation biological assessments pose enormous commitment of time and money. Take the case of the Nellis Air Force Range in Nevada. BLM received the following biological opinion:

A study should be conducted to:

(1) Determine all candidate and proposed threatened or endangered plant species which occur on the Nellis Range.

(2) Delineate the exact locations of such populations.

Such a study should be for at least one full collecting season during an average moisture year and prior to *any* activities that might jeopardize the existance of the subject species.

The above instructions for conducting the study are botanically sound, by reason of the fact that seeds of many species lie dormant in the soils of the arid Southwest for years awaiting an infrequent rain. Then rapidly the full plant cycle is completed while moisture is still available. But how do you foretell an adequate moisture regime? How do you fit such an indefinite timetable for survey and site mapping of arid-land plants into the hard realistic schedules of construction if it is to be cost effective and available when needed?

Summary: Under the 1978 version of the act, preconsultation biological assessments will be the responsibility of agencies seeking approval of programs authorized, funded, or conducted by them. The above examples illustrate the potential for delaying the start of the project and for adding (sometimes significantly) to the overall costs. It would seem that regulations have been imposed to protect animals and plants against extinction before there is any very precise knowledge of the tens of thousands of little-known or inconspicuous species of nongame animals, particularly invertebrates, and even less of plant species we have not chosen to propagate or value for their form or floral display.

Withdrawal of Resources

There is no way to avoid the commitment of natural resource if an endangered species habitat is to be protected. Some of these resources we can easily share, and others are not in excess of our economic needs. This is not to say that resources reserved to endangered species are irretrievably lost—but for current use they are not available, and this can seriously impact local industries dependent upon them for ongoing supplies.

For example, the U.S. Forest Service has presently located some 2,000 nesting colonies of Red-cockaded Woodpeckers in southeastern national forests. It has been determined that each colony nesting site averages 10 acres. One fourth of the colonies require an additional 25-acre recruitment area. This is a total of 70,000 acres in merchantable timber currently removed. The eventual goal is to have four such colonies per 1,000 acres, which would entail setting aside 140 acres/1,000 acres in suitable timber. There is an estimated 6,000,000 acres of pine types in the Red-cockaded Woodpecker's range on national forests. If the goal is eventually attained, it will mean that 840,000 acres of commercial timber is being devoted to the protection of one single endangered species.

While there is no system-wide management plan, several regions of the national forests have adopted the practice of setting aside against any modification eight acres about each Bald Eagle nest tree, together with an additional buffer zone limiting activities during the nesting season. In Alaska 2,760 Bald Eagle nests have been located and charted, thus automatically setting aside some 21,500 acres of merchantable timber. However, land use plans for national forests in southeast Alaska call for the reservation of approximately 50,680 acres of standard operable commercial timberlands along beach

areas, primarily for the protection of eagle habitat.

The endangered Kirtland's Warbler nests in northern Michigan in an early successional stage following fire. Here Jack Pine boughs screen a ground nest in a more or less contiguous low blueberry ground cover. The recovery plan calls for managing some 61,485 acres of Jack Pine on the Huron National Forest, by controlled burning, to provide this habitat. Elsewhere, on the Six Rivers National Forest in California a proposed timber sale of approximately 9.25 MMBF of merchantable timber was withdrawn to protect an endangered plant (Pine-foot). In New Mexico, the endangered Jemes Mountain Salamander requires deep shade and substantial amounts of moist, decomposing timber material on rocky north slopes. The management plan may withdraw as much as 2,500 acres to protect this habitat, though admittedly the timber is difficult to harvest. In Montana, habitat protection for the grizzly bear tends to limit the salvage of beetle-killed timber.

In a number of cases, *one* of the reasons given for listing an animal or plant as endangered is overgrazing. However, thus far only one proposal to close an area to grazing has surfaced. This is the Beaver Dam Slope area in southeastern Nevada, for the purpose of protecting the Desert Tortoise. But withdrawal of public range can take a number of forms. For example, prairie dog colonies on the Buffalo Gap National Grasslands in South Dakota have increased from 114 in 1968 to 479 in 1975—and the area occupied from 3,000 to 18,000 acres. Because of the endangered Black Footed Ferret that uses the prairie dog as a principal prey, the simple solution of removing these rodents to the point where range forage conditions improve is not acceptable. So the management plan calls for partial reduction in prairie dog numbers, accompanied by a reduction in livestock grazing that would have produced 319,000 pounds of beef.

But of resources in the western United States that are less than adequate for man's needs, water stands first. The most productive place to look for an endangered or threatened species is in an isolated spring or sink. Isolation created the adapting species and that same restricted habitat endangers them. These sites are very susceptible to withdrawal of water from underground aquifers for domestic use or irrigation. Thus, the Desert Pupfish prevailed in stopping a rancher from irrigating his alfalfa fields. In southwestern Texas three small fish inhabiting springs and headwaters of drainages to the Amistad Reservoir are proposed as endangered and/or threatened, the major reason being "excessive removal of ground water." Water uses in an area starved for that commodity can be affected many miles distant.

Even cities are vulnerable to this type of resource withdrawal. For example, to insure adequate water for future needs, the city of Cheyenne, Wyoming, acquired the water rights from the Little Snake River on the western slope, which they would bring through a tunnel under the Divide to Cheyenne. But below the water takeout points is the stream habitat of the Colorado Cutthroat Trout, considered for protective listing. To solve the impasse, Cheyenne agreed to release 5,000 acre feet of their anticipated 23,000 acre feet of water to maintain the trout habitat. The value of the water to the city is much greater than the $110 per acre foot necessary to develop the water collection project ($550,000 for this fraction).

The life's blood of the southwestern United States is the Colorado River drainage basin. It holds the key to every activity. Endangered species of fish have now been listed for different segments of this river system from Wyoming to Arizona. The impact of this program in so sensitive an area can be explosive.

Costly Project Modifications

The regional office of the U.S. Forest Service in California informed me in August 1978 that they had made 22 requests of the Endangered Species Office for formal Section 7 Consultations. At that time they had received 10 completed biological opinions, half of which recommended modification of a program. Similarly, the regional office of the Forest Service in Montana had received final biological opinions on five programs, 80 percent of this number recommending changes. Many of the project modifications were the product of interagency planning that min-

imized cost and disruption. But others add appreciably to project costs.

The Florida Power and Light Company, serving the electric needs of southeastern Florida, is literally being painted into a corner by a maze of conservation set-aside areas, including critical habitats for four endangered species. They sought permission to build a transmission line to cross about a mile of one corner of the Loxahatchee Wildlife Refuge. They offered to purchase another tract of land of equal value that would be suitable habitat and, in addition, provide $1 million for its development. They failed to get the easement because it was "incompatible with the Everglade Kite Critical Habitat." The line has now been detoured around that corner of the refuge at an additional cost for construction of $1,200,000. The public utility contends that the easement they sought contained neither Everglade Kites nor the Apple Snail on which they feed.

Clear across the continent another public utility, Southern California Edison, experienced increased project costs of a somewhat different nature. A 17-mile equipment haul route to the San Onofre Nuclear Generating Station near San Clemente, California, from the off-loading dock was required. Due to terrain, land ownership, and load weight constraints, the route was to follow along the coastal beach just above the high tide line. During 1976, a portion of the route became populated with a colony of Least Terns. After several meetings with the Least Tern Recovery Team, it became obvious that a new haul route and/or construction schedules and equipment delivery times would have to be changed. The studies and altered schedules to avoid equipment arrival during nesting period (April–September) resulted in direct costs of approximately $800,000.

In northern Colorado, the Peabody Coal Company was enlarging its mining operation, which is to serve as the sole fuel source for Colorado-Ute's Power Plant at Hayden. Peabody had surveyed and purchased a right-of-way for a haul road to deliver the coal when a local staff member of the Colorado Division of Wildlife called attention to a cultivated wheat field along the route that was used each spring by a small group of Greater Sandhill Cranes. These migratory stop-over sites are termed "dancing grounds" because certain prebreeding rituals take place in this period. Peabody had prepared an Environmental Impact Study on their program and circulated it to state agencies, but it evidently did not come to the attention of anyone knowledgeable about the cranes. The greater Sandhill Crane is on the Colorado state list as endangered, but not on the federal. This situation required Peabody to reroute their delivery road and purchase a new right-of-way.

The Arkansas State Highway Department, although filing a formal request for a Section 7 Consultation on the proposed routing of a four-lane highway, decided independently on an alternate route to avoid the cave habitat of the federally endangered Gray Bat and a state-listed cavefish and grotto salamander. The envisioned adverse affects were not the physical disruption of the right-of-way, but the off-chance that a chemical spill would occur on the completed highway that would enter the underground aquifer that feeds a more distant cave. This alternate action lengthened the highway by a little over two miles, which will cost taxpayers an estimated $3,000,000.

Addressing Problems, Not Solutions

The Soil Conservation Service has had some rather difficult experiences with the endangered species legislation. A small watershed program has broad participation of affected parties in project planning. The usual goal is to prevent the loss of topsoil in the upper basin and destructive flooding in the lower basin, and to improve permanent water sources, be it stream flow or small reservoir.

The Cypress Creek Watershed in Lauderdale County, Alabama, and Wayne County, Tennessee, was just such a project. But the biological assessment that SCS funded turned up an endangered small fish, the Slackwater Darter, one of 80 species and subspecies of darters in Tennessee. The biological opinion from the Office of Endangered Species pointed out that the project would adversely affect the Slackwater Darter because of its very unusual reproductive requirements. While typical of a slow-flowing stream with silt and

gravel bottom, this Darter makes use of high (flood) water to swim off-stream into seepage areas in open pastures for breeding. OES approved four water retarding structures on Little Cypress where no darters were found, but blue-penciled for the time being 15 structures on other branches of the system. This darter needs flooding, but the fields and small towns down valley don't.

In Mississippi, after identification of the Bayou Darter in the Bayou Pierre Watershed, over $100,000 was spent by SCS to identify the habitat and critical elements of that habitat. Planning and taking into account habitat location and the critical elements of the habitat resulted in selecting land treatment and 13 floodwater retarding structures as the proper approach. An analysis of impacts on the scope and extent of habitat and the critical factors in the habitat indicated no significant impact on the Bayou Darter. But the Office of Endangered Species disagreed. High on their list of reasoning was the *inability to predict induced land changes* that might be accompanied by increased pesticide residues, siltation, etc. This would not appear to be an objection to the project per se, but to the opportunity it provided individuals within the improved watershed to upgrade their economic pursuits which just might adversely affect the darter.

Conclusion

The impacts of the Endangered Species Act have so many facets and ramify into so many corners of our society that it has been impossible in a short paper to bring you very much of the information finding its way across my desk in the last three months. However, it should be abundantly clear that much of the burden of performing research and adjusting to endangered species requirements is falling outside the coterie of government agencies, private organizations, and individuals who are expressly committed to the management of wildlife and native plants. Imposing that obligation places a critical responsibility on those wielding the legislation to fully determine that the programs are biologically sound and economically practical. As the list of endangered species grows, it will take the wisdom of Solomon to avoid fencing in the economy until it will no longer serve you. You have very little time to establish a favorable rapport, for the program comes up for another congressional review in one and one-half years. You have this in your favor: there is almost no one who doesn't enjoy some aspect of the living world about us.

Questions to Dr. Spencer

Q. If I interpret your comments correctly and place them into a context of the relationship they might have to those of Dr. Clement, there is a real, immediate requirement for changing some of the cultural practices we presently have. Is this interpretation correct?

A. I am sorry folks. I live in a pretty practical world and am not prepared to go into the theories and philosophies of management. So if I may, I am going to duck that question.

Earlier this morning one of our speakers said that he was often asked, "What is the value of a given endangered species and how do you compare it with the costs that we are going to face in providing priority-use habitats?" The House/Senate Conference Report (No. 95-1804, dated 15 October 1978) has this to say:

> . . . to balance the benefits associated with the agency action against the benefits associated with alternative courses of action, they should not balance the benefits of the action against the value associated with the listed species.

I take this to mean that there is to be no attempt to place a monetary value on a species threatened with extinction. In other words, the instruction is to compare the economic impact of the different alternative actions, but not to place a value on wildlife for the purposes of comparative costs.

Q. That is correct. It is an act of Congress, I think.

A. It is in the Endangered Species Act Amendments of 1978. The Solicitor General's Office will provide decisions on these matters.

Q. Several of your comments were directed toward the relative costs of changing a project or altering a project in order to be in accord with the Endangered Species Act. You seem to be saying by this that it costs a lot of money for other government agencies, private companies, and the like to accommodate their designs with the requirements of the Endangered Species Act. I won't argue with that. It's true. It seems that we need a priority system to go along with it. As an example, let me tell you a little story. I had to do an environmental impact statement for a power line. The question in my mind was, "Is this power line needed?" I never got a satisfactory answer from the power company or anyone else that it was necessary. It seems to me that we need a priority system whereby we can feed that kind of information into the decision-making process because it is possible that someone might plan something without a real need for it.

A. I would suggest that this is not a normal procedure. People generally do not build what they do not need. It is normal not to encumber an expense un-

less you anticipate some beneficial return. Before being too hasty to ascribe a motive to a person, organization, or project to which we might have some objection, I suggest we follow the motto that says, "Don't criticize your opponent until you have walked a mile in his moccasins."

Q. The other point I thought you were trying to make is that people here in the audience ought to be aware that there is a very bad economic penalty or economic cost, if you want to put it in those terms, with this particular piece of legislation and that if we fail to recognize those costs that are there, we may be in jeopardy of losing the program entirely.

A. You have stated my opinion very well. We are proud of what we have been able to accomplish in wildlife conservation in this country. Until very recently, these wildlife programs have been totally self-supporting and have not dipped into the tax till to which the general public contributes. Now we have turned around and are progressively passing the costs along to companies, organizations, and the general public for projects in which they have little first-hand interest. It is up to us to be sure that the cooperation we ask of them is a wise investment for all parties.

The new environmental laws, including the Endangered Species Act, came into being during a period when we were economically well off. Now we are experiencing a period of inflation, high taxes, and a cost of living that is affecting every pocketbook. It is time for us to be very, very careful we don't crowd this unfavorable economy. If we ask for too much, if we wield this powerful legislation with too much enthusiastic abandon, we stand to have Congress remove it from the books. Please remember it comes up in Congress for reappropriation in 18 months. In the 39 years I worked for the federal government, 34 of those years with the Fish and Wildlife Service, every time the economy dipped our appropriations were among the first to be cut. I don't think times have changed.

There are relatively few endangered and threatened species on the lists at the present time compared to literally thousands that only await the proper study to be added. We have established critical habitat for only 33—a not too complicated procedure when only one species in an area is considered. But in the future, you can anticipate that critical habitats will involve acreages and overlaps that will noticeably fence in the economy.

In my opinion, the 25 amendments to the Endangered Species Act in 1978 succeeded only in making the legislation more difficult to administer, and equally more difficult to comply with. It is now so complex that it is self-defeating.

ENDANGERED ANIMALS IN UTAH AND ADJACENT AREAS

Douglas Day[1]

Abstract.— This paper presents a brief background on Utah's experience with the Endangered Species Act of 1973 to date, the Division of Wildlife Resources' involvement with resident endangered wildlife forms, including the Utah prairie dog, peregrine falcon, bald eagle, woundfin, Colorado squawfish and humpback chub, and problems associated with the listing of native fauna. Also discussed is a proposal to vest the division with authority for endangered plants by legislative mandate.

I appreciate that kind introduction—and it's true, I am a son-in-law of Dr. Clarence Cottam. I was debating whether to mention that or not, but it has come up. Let me just pay tribute to Dr. Cottam, as the personal relationship I had with him was something special, and I think that the reason I'm here today is because of the special interest he showed in me. I can remember looking for whooping cranes at the Arkansas Refuge. He wanted to make sure I got a firsthand impression of those magnificent birds, and that impression has stayed with me throughout my life. I remember staying out at night with Dr. Cottam on the Welder Refuge, trying to call up the Texas red wolf. His keen interest in endangered species was inspiring. I'll never forget it. He has been a great influence in my life. Also, I know he provided some direction to BYU's biological endeavors.

Talking about endangered species, I think I might be one. In the position that I'm in as director of Utah's Division of Wildlife Resources, I think I have a feeling for these critters that we're talking about. I'm kind of caught between two worlds—the political world and the world that we have worked in so many years in the biological realm. To make those worlds see eye to eye is very difficult. That's sometimes why I think directors are endangered—because they might get a little too enthusiastic about the biological part of it and forget the political part. It's a tightrope to walk. Sometimes we don't have the opportunity to say what we really feel. Someone gets to the public before we do and says this is what they think, and prudence requires that we wait for a better opportunity. Sooner or later it seems to come. I think the time might come, if we keep going in the direction we're going in disregarding environmental concerns, that someone might just happen to have an idea that the whole world should be declared critical habitat. If that happens, I don't think we'll have to worry about collecting permits.

I'd like to make a couple of comments on a pending court case. The defendants are the secretary of the interior, the governor of Colorado, the director of the Colorado Division of Wildlife, the governor of Utah, Utah's director of the Department of Natural Resources, and I. This lawsuit is over threatened and endangered species. In that lawsuit it is mentioned that "The right to develop and beneficially consume the limited quantity of water . . . (from the Colorado River) is a vested property right, the use of which is protected to the citizens, present and future. . . ." Now, I would ask the question—does wildlife have any vested property rights? I submit that it hadn't, not until the Endangered Species Act of 1973. That's very important—to realize why we need to protect and hold on to the Endangered Species Act. In that lawsuit some of the claims are the defendants failed to properly, fairly, equitably, and impartially enforce the provisions of the Endangered Species Act. Continuing on, the lawsuit further states, "The factual basis upon which the determination was made that the Colorado Squawfish and the Humpback

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Chub are or were 'threatened with extinction,' and the continued designation under ESA as 'endangered' was and is not based upon sound and adequate biological data and knowledge of said species . . . and, further, amount to arbitrary and capricious acts on the part of the defendants. . . ."

Here is another item, "The defendants, and all of them, have determined without adequate biological data and knowledge that water impoundment development adversely affect such fish species. . . , and as a result of said erroneous conclusions, based upon little or no scientific evidence, defendants have continued to wrongfully impede plaintiff districts' efforts to construct their projects, including impoundments. . . ."

And last, another excerpt I thought would be of interest to you, is "The fact that Colorado Squawfish, and the Humpback Chub, were allegedly 'threatened with extinction' and are now allegedly 'endangered' is the direct and proximate result of the stocking by all defendants of non-endemic, non-native or exotic fishes in the Colorado System." What that means is that the stripers are eating the squawfish. I suggested a proposition or a proposal that might be humorous in one way but sad in another, that being, if they really want to stop the stripers from eating the squawfish (there is no scientific evidence of this), why don't they build another dam on the Colorado River to keep stripers from running upstream. I don't know what the outcome of all this will be.

My time is rather limited, but I want to draw your attention to last Sunday's *Parade* magazine. I am pleased that we are getting this kind of coverage. What it says is the two things that are the greatest threat to wildlife today are (1) loss of habitat (and that's very obvious, because if endangered species had good habitat they wouldn't be in danger) and (2) commercialization of world wildlife. Consider these statistics from the U.S. Fish and Wildlife Service. Last year in the United States we imported about 100 million tropical fish, 500,000 reptiles, 100,000 mammals, and uncounted thousands of birds. The imported traffic in manufactured wildlife goods—furs, coats, leather, trinkets, jewelry, and carvings—leaped from 1.7 million items in 1972 to 91 million in 1976, the last year for which figures are available. Between 1973 and 1976, skin and hide imports rose from 900,000 to 32.5 million. Part of the reason is the impact from TV of Barretta's bird, Fred. A few years ago you could buy a cockatoo for $100, and now some of them are fetching $6,000 apiece.

Let me go into some of our involvement in the State Wildlife Division with endangered species. I'll tell you about a few of the species we're working with and about some of the progress we are making. But first, I want to take just a minute and maybe leave you with another concept. I've worked closely with the Boy Scouts for a number of years, and I had the opportunity to take them to a power plant. One thing that impressed us was the control room. In that control room you could virtually feel the whole operation of the plant. It was right there; you knew what was happening, and when there was a problem somewhere a red light came on. The plant operator could tell where that problem was from the red light.

I would submit to you that in the biological world we have our red lights. We don't pay much attention to them, or haven't done until lately. These red lights are our endangered species. I think that is a good concept. I noticed yesterday morning driving to the office a pickup truck that I was following was obviously losing its antifreeze, and I could predict what would happen; the red light came on and the truck was in trouble. He could go on a little while, but eventually it had to be taken care of or that truck was doomed. The operator obviously paid attention to the warning light and pulled off the road.

In the biological world we don't pay attention to our red lights as we should. We're just beginning to do this. These are our endangered species. This much-used and publicized terminology connotes a wildlife form desperately trying not to join the passenger pigeon, heath hen, and others in the land of memory. Each time we lose a species one of our red lights goes out.

This designation of endangered species has also been accused of holding up progress and projects, locking up land, and various other alleged abuses. The Endangered Species Acts of 1966 and 1969 were relatively innocuous

in that they recognized the status of certain species and listed them, but it took the Endangered Species Act of 1973 to establish a national policy to come to grips with the issue and determine ways and means to attempt to reverse the trends of certain species toward extinction.

To a state wildlife administrator, the 1973 Act with its attendant rule making and restrictions has been the source of much soul searching. I believe most of us wholeheartedly agreed with the philosophy and the intent of Congress. We have vigorously objected to the early federal agency approach that absolutely usurps state authority in endangered species management. Recent developments have ameliorated the situation, and on the horizon I can see finally the development of a much closer state-federal working relationship with the goal of doing all humanly possible to restore endangered species to a viable component of our environment. The sadness in the situation is that it has taken almost five years to get to this point. This is time that we can't afford to waste. However, in defense of the federal agency's past position, let me add that the act itself, until amended, left no room for legitimate compromise. This in itself has been a big stumbling block.

I remember another Cottam that you are well acquainted with here at BYU, and that is Dr. Walter Cottam. He said, "Unless you learn somehow to compete with the dollar, you will lose the conservation battle." In my experience, and ever since I have been involved, it has been a compromise situation. I am afraid the direction we are going is compromise to extinction unless we reverse that trend. We are just beginning to get some tools that give us a little bit of an edge in the compromise situation. Because of the developmental demands in our environment, it is not easy to carry on this struggle we are in. Believe me, it is discouraging. I can remember only one instance when a developer came on his own to a wildlife biologist for input into a development project. It is sad that we have endangered species acts and other legislation to require coordination and consultation between developers and biologists.

The real plus for the act has been the awakening interest in the amount of knowledge about many species we never before considered as significant, or for that matter as ever existing. In retrospect, our formal training in the field was deficient in many areas but suited the times. Unfortunately, industrialization, social pressure, and human demands accelerated at a rate faster than the state of the art of wildlife management. Related fields of plant and animal science have produced knowledgeable individuals who have "come out of the woodwork," so to speak, with indisputable evidence regarding certain species that state management agencies were never privy to, were unaware of, or disregarded.

For many years we have been game oriented, not always by choice, but by the unrelenting force of simple economics. Until 1975, in Utah, our entire program was financed by user fees in the form of hunting and fishing licenses, fines and forfeitures, matching federal monies also paid by hunters and fishermen, and miscellaneous sources. It is obvious our primary mission has been to provide for and produce those species sought after by those paying the bill. In 1975 the Utah Legislature provided general funds to implement a modest nongame section within the division and has continued that support, still modest in terms of total budget. There is a legitimate need to increase funding for nongame programs, to increase our capabilities to provide basic knowledge and solutions to current problems. Appropriate emphasis is being placed on endangered species within this nongame section.

With this background, let me detail programs related to endangered species in Utah. First, let me say that we have yet to enter into a formal cooperative agreement with the U.S. Fish and Wildlife Service under terms of the Endangered Species Act. Recent congressional action provides for new rule making allowing us to do this, and we expect to sign such an agreement. However, the lack of a formal agreement dampened neither our dedication nor enthusiasm to get on with the job that needed doing.

In 1973, under a special cooperative agreement with the Denver Regional Office of the U.S. Fish and Wildlife Service, funds were provided to survey historical and potential habitat of the Utah prairie dog (*Cynomys*

parvidens). This is our start. As an endangered species, this animal has had an erratic history. It was first added to the list in 1969, removed in 1970, and added again in June 1973. Since our initial effort in identifying habitat, the original agreement has been amended annually, providing funds each year to continue our trapping and transplanting programs. In spite of its endangered species status, based on overall population and status of colonies, those found in private agricultural lands have provided us an annual problem of some magnitude. It is from these damage situations that we trap and attempt to establish new colonies in areas of historical occupancy on public lands. Trapping commences in the spring before the young are born, ceases until young are weaned, and resumes and continues until late summer. Our most recent technique attempts to livetrap family groups for relocation. The work is carried out using seasonal employees supervised by our regional office in Cedar City under guidelines from our nongame section.

We have come under criticism from one animal protection organization for what appears to them to be a low success rate of survival and establishment from our transplant program. Also, that organization is critical of our numbers for the species as compared to the estimated population in 1973. All I can offer is that, because we are not sure of a percentage to project for a total population, we will continue to use our maximum counts as a minimum population figure. I am sure that our sincere efforts to alleviate agricultural damage has kept some landowners from taking matters into their own hands. Even if we are losing large numbers in an attempt to establish a new colony, it appears to us to be a wiser decision than to possibly lose the same number or more without having taken the risk. We are not happy with the odds either, but restoration of any species is fraught with failures, disappointments, and frustrations. We are only human in recognizing and being affected by them but feel that we are also professional in not giving up and in genuinely trying to reduce these failures, disappointments, and frustrations. We are confident that the Utah prairie dog will soon be in a secure enough position from the standpoint of new colonies on public lands that we can successfully petition for delisting. What we attempt to do is investigate the problem, do the research necessary, and give some management that will ensure an environment in which the species can live and reproduce and have some kind of continuance. It takes management.

In May 1975, before authorized funding for our nongame program became effective, we concluded, in an agreement with the U.S. Fish and Wildlife Service and Bureau of Land Management, to jointly fund the division position of raptor biologist. Our share was funded through monies received as contribution from private citizens. This arrangement continues to this day, except that our share has been funded by legislative appropriation since 1 July 1976.

Our work with raptors includes all species, with emphasis on those endangered, sensitive, or unique. The American peregrine falcon (*Falco peregrinus anatum*) is of primary concern in view of its current national status. Based on historic records, Utah had the highest rate of occupancy by this subspecies of any western state with the possible exception of California. You are all aware of the dramatic decline in the West and the extirpation of the falcon in the East and the possible causes. From the middle sixties to 1975 there were no known active peregrine eyries in Utah; at least none were revealed to us. In 1978, we documented occupancy at four sights, but funding limitations allowed no data to be gathered through our efforts—that was because of a lack of personnel. We do what we can. Whether the peregrine is staging a comeback is a matter of conjecture. We doubt it. Increased awareness of its plight is probably the reason for recent documentation, plus limited additional effort to seek out the presence of the species. Evidence available indicates pesticide residues are still too high to cause much optimism at this point. We will continue to put as much effort to determining status as funds and personnel will allow. This activity will increase when Endangered Species Act funds become available to us.

This year the bald eagle (*Haliaeetus leucocephalus*) was added to the list of U.S. threatened and endangered species. Previously only those bald eagles nesting south

of the 40th parallel were listed. This action has caused us no little concern because we have no documentation of nesting bald eagles in Utah, but each winter we are visited by over 600 eagles produced from as far away as northern Saskatchewan. The population seems thriving and secure there, and we are at a loss to explain how their plight changes as they wing their way over a political boundary. I am reminded of a settler who was living up in that area along the United States-Canadian boundary at the time they surveyed our modern boundary lines. He found out through the survey that he was actually in the United States. He said, "Thank God. I couldn't have stood another Canadian winter."

We protected the listing for several reasons, but the one of the greatest magnitude and potential problem is that of critical habitat designation if the action ever comes to pass. Every canyon used for night roosting, every tree used for day resting, every hunting area could come under the designation. What would happen to our waterfowl management areas upon which so many nonhunted species depend if federal funds were withheld for failure to limit hunting because of the presence of bald eagles? Today there hasn't been a hint of such action, but stranger things have happened. Before the recent listing, we initiated a survey of bald eagle visitants, and for the past five years have documented number, preferred location of use, and general arrival and departure dates. This year, in addition to our own winter census, we will participate in the national one-day bald eagle census in cooperation with the National Wildlife Federation.

I want to talk for a minute about one other species, mention some fishes, and then wind it up. The desert tortoise (*Gopherus agassizi*) was mentioned earlier this morning. Recently the U.S. Fish and Wildlife Service has proposed, by *Federal Register* publication, listing of the desert tortoise as an endangered species along with designation of 38 square miles of the Beaver Dam slope in Washington County as critical habitat. We have been actively involved in recent years in documenting the current status of the tortoise and the condition of its habitat. While sympathetic to its plight, we believe this move to be premature in that studies currently under way in Arizona immediately adjacent should be finished and evaluated and the entire system looked at rather than drawing political boundaries to attempt management of a species.

I will touch only briefly on the endangered fishes here in Utah. I am sure Dr. Deacon will provide more in-depth summary in his presentation. There are presently three species in Utah in this category. They are the Colorado squawfish (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*) in the mainstream Colorado and Green rivers in Utah and the woundfin (*Plagopterus argentissimus*) found in the Virgin River below LaVerkin Springs. There are three more species currently under consideration for either threatened or endangered status—the razorback sucker (*Xyrauchen texanus*) and bonytail chub (*Gila elegans*) in the mainstream Colorado system and the Virgin River roundtail chub (*Gila robusta seminuda*). Our past work with these has been very limited, paricularly with the Virgin River species. Recently, we have been more involved and expect to fulfill our role as fish and wildlife managers as funds are made available.

It now appears our next step may be into the area of endangered plants. In a few minutes you will hear more of the status of certain plant species from persons more knowledgeable than I; however, the Utah Science Advisory Committee has prepared legislation for introduction at the general session of the legislature in January that will give our division jurisdiction over those plant species declared threatened or endangered under the act. It also provides for the establishment of a position of taxonomist and funding to carry out the necessary activities. If this comes to pass, we will be drawing heavily for some time on the expertise of several of the speakers at this symposium.

Our involvement with endangered species to this point, though not deep, has been substantial considering the minimal funding received under the act for just one facet of the program. Recovery teams are in operation for all Utah species, and we have representatives for all but the bald eagle. Our participation has been active and sincere. We take the task seriously and intend to continue to pro-

vide meaningful input for the sake of the species involved. We also intend to cooperate with other states, federal agencies, and all interests to ensure that endangered species are provided for, keeping in perspective the needs of all wildlife as well as those various interests of our human resource. I hope our efforts will be interpreted in this light.

QUESTIONS TO MR. DAY

Q. We agree with your present analysis of the situation. If you find a better solution, please let us know.

A. I think what we in wildlife management have to do is to make intelligent decisions concerning endangered species and keep the pendulum from swinging too far the other way. We don't want to lose this tool, as I mentioned before, and I think you can see what effect the politician has on the direction we go.

Q. I'm not sure where these big birds move in from, but in the Uinta Basin there's quite a wintering population of bald eagles which comes in and feeds on the waterfowl of the Pacific flyway that goes through that area. There is an area there that came to be recognized as a roost area where the birds go back and rest in the evening and spend the night. Such areas have been given refuge status in Oregon.

A. Well those things happen. We need to use prudence in recognizing these areas or things can get out of hand.

Q. Do I sense an opposition to listing any critical habitat in Utah?

A. From our division? We don't list it. We are not opposed to critical habitat designations if needed.

Q. Well, Dr. Murphy said the same thing there and I was wondering if . . .

A. No, when you get down to specific cases, whatever is needed, whatever the facts require to ensure the survival of that species at an intelligent level—that ought to be the way we are managing it. You can see what the reaction of the public and the politician is to situations where we go overboard.

Dr. Murphy: There are several large and important roosts that would fit the category of the one he mentions in the Uinta Basin that I would be very happy to see listed as critical habitat, but it's just that the wintering population becomes very disbursed and small groups will be found in small areas all over the state. It becomes almost administratively impossible to keep up with that kind of a situation.

Q. I would like to ask you a question that is perhaps out of your realm, and that is "what is the policy of the state with regard to endangered species, particularly plants on state land?"

A. A lot of people have been asking me those kinds of questions lately. I guess first we'd have to know what the management implications are. You've got the other species I mentioned, the resources, the rehabilitation projects going on for game species, and that type of thing. I can only answer, just in a general way, that we're interested. We want to see these identified and take intelligent measures to protect habitat and species.

Q. Specifically, what about the *Cactus rideii* on the Mancos Shale in the Citros Butte area of Wayne County which is being strip mined for coal and is in an area of critical habitat for that species?

A. You remind me of a story that will maybe get me off the hook. This fellow was a well-known speaker. He gave this talk, and his chauffeur drove him around to all these places, and his chauffeur said one day, "Let me give this talk for you. I've heard it so many times I can do it as well as you can."

So he said, "OK, I'll wear your chauffeur's uniform and you give the talk."

That happened. The audience applauded, and then it came time for the questions. That's the situation I'm in. A question like this came up, and he said, "That's one of the simplest questions I've ever heard, and to show you how simple it is, I'm going to let my chauffeur answer it." The problem is that I didn't bring my chauffeur.

We'll work with you. Let me just indicate that state lands are not our wildlife lands, but lands under the State Land Board. I'm not happy with the past management of state lands. Overgrazing has been a continual problem since early in Utah history. We're stuck with the rehabilitation. I've seen that overgrazing. The most recent time was the bow hunt this fall on the Manti Forest. You can look at the museum pictures of overgrazing and you can go out on Fred's Flat today and identify those same pictures without a camera. If you don't learn from history, you're bound to make the same mistakes.

ENDANGERED AND THREATENED FISHES OF THE WEST

James E. Deacon[1]

Abstract.— The endangered and threatened fish fauna of the United States exhibits problems resulting primarily from habitat modification by man. The evolutionary history of the fauna has left it especially sensitive to biotic interactions. In addition, many forms are of such restricted distribution that the entire taxon can be destroyed by very minor perturbations. The effects of habitat modification on woundfin and roundtail chub in the Virgin River of Utah, Arizona, and Nevada are discussed. Parasitism by *Lernea* on White River springfish is shown to coincide with population decline in some, but not all, cases. Population declines of Pahrump killifish are related to biotic interactions with both goldfish and mosquitofish. Population size of Devils Hole pupfish are shown to be quite responsive to small changes in habitat availability.

Fishes of the West are affected by the same general kinds of ecological problems that are causing extinctions throughout the world. The interplay of economics with perceived value in society has led us into the numerous ecological problems facing us today. There is some evidence to suggest that society is making some preliminary effort to slow the rate of extermination. Perhaps this is happening because the conclusions of ecologists, philosophers, and theologians regarding the relationship of man and environment are to some extent being translated into legislation as well as into conventional wisdom.

The fish fauna of the western United States has frequently been characterized as one having a relatively low diversity and containing an unusually high percentage of endemic taxa exhibiting limited distributions (Miller 1959, Smith 1978). These appear also to be the primary features contributing to the fact that much of the fauna is threatened to some degree.

Recently, the Endangered Species Committee of the American Fisheries Society compiled a listing of threatened fishes of North America (Deacon et al. 1979). The fishes on that list from the western United States are presented here as a data base for the general discussion (Tables 5 and 6). The predominant threats to all taxa listed were generalized into five broad categories and each taxon was assigned one or more of these categories. Threat categories were as follows: (1) The present or threatened destruction, modification, or curtailment of the habitat or range. (2) Overutilization for commercial, sporting, scientific, or educational purposes. (3) Disease or parasitism. (4) Other natural or manmade factors affecting continued existence (hybridization, introduction of exotic or translocated species, predation, competition). (5) Restricted range of the taxon. A comparison of threats to western fishes north of Mexico with those to eastern fishes is of general interest and illustrates significant differences between the two faunas (Table 1).

Habitat modification (Category 1) is clearly the most prevalent threat to native fishes throughout the world, and this is certainly true in North America. There are a few species in the West, however, that are not now so threatened. No eastern species, however, has escaped problems raised by physical alteration of the habitat.

No western species has been or is threatened by overexploitation (Category 2), but about 7 percent of the eastern fishes on the list are or were so threatened. Six species of ciscoes occurring in the Great Lakes were subjected to overfishing by commercial fishermen, changes resulting from the introduction of the sea lamprey, and general environmental degradation (Scott and Crossman 1973). In addition, the Atlantic whitefish has been subjected to overfishing as well as habitat alteration. They represent the only fish taxa in the United States or Canada to be on the American Fisheries Society list of threatened species, in part, because of overexploitation.

Disease and parasitism (Category 3) have

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apparently not been involved in threats to any eastern species on the list but have been factors for about 4 percent of the western fishes. It is probable that this difference results from the fact that information regarding incidence of disease and parasitism in native fishes is relatively sparse. In addition, though the initial major decline in abundance and distribution of eastern fishes probably occurred prior to 1850 (Trautman 1957), in the West the similar event occurred subsequent to 1850 (Miller 1961). Because increased incidence of disease and/or parasitism as an important factor in a population decline becomes most apparent during the major decline, it must be detected at that time to be recognized. The generally earlier decline of eastern fishes during a time when increased incidence of disease or parasitism would have been less likely to have either been detected or associated with the decline probably explains its absence from association with the eastern fauna. This factor doubtless has been a more important contributor to decline of both eastern and western fish populations than is apparent. It has specifically been identified by Wilson et al. (1966) and Seethaler (1978) as a factor in the decline of western fishes.

Biological interactions of various kinds (Category 4) contribute to the problems faced by 54 percent of the threatened western fauna but only 9 percent of the threatened eastern fauna. The marked differences in Category 4 point to distinctions of the western fish fauna that have been repeatedly discussed. Physical barriers to dispersal have resulted in relatively low colonization rates throughout the West, with the consequence that western fish faunas are not especially speciose (Smith 1978). Because their evolutionary experiences have been with relatively depauperate faunas, western fishes have relatively low tolerances to biological interactions (Smith 1978, Deacon and Minckley 1974, Hubbs et al. 1974).

A restricted range (occurring in only a single spring, a single group of springs, or a short stretch of stream [Category 5]) is a factor involved in giving a threatened status to 21 percent of the western fishes listed, but only about 7 percent of the eastern fishes. Category 5 illustrates the fact that one group of western fishes appears to have a high degree of "extinction resistance" (Smith 1978). The consequence is that many western taxa exist as relict populations in single habitats. They found their way onto the AFS list of threatened fishes because of that fact. They, like many western fishes, generally have high tolerances to physical extremes but low tolerances to biological interactions (Deacon and Minckley 1974).

Physical Modification of Habitats

While western fishes have in general developed considerable resistance to the physical extremes imposed upon them by climatic factors, they have also been most strongly affected by general and specific alterations of physical habitats imposed upon them by man. Miller (1961), Hastings and Turner (1965), and Cottam (1961) have dramatically shown the impact of slight climatic shifts superimposed on removal of vegetative cover by overgrazing between about 1880 and 1900. The arroyo cutting, siltation, and dewatering that occurred during this period were probably the most detrimental 20 years

TABLE 1. Comparison of general kinds of threats to the threatened freshwater fish fauna of western and eastern North America, north of Mexico.

	Western Fishes		Eastern Fishes	
General threat category	Number of taxa (N = 112)	Percent of fauna affected	Number of taxa (N = 90)	Percent of fauna affected
1. Habitat modification	109	97.3	90	100
2. Overexploitation	0	0	6	6.7
3. Parasitism and disease	5	4.4	0	0
4. Biotic interactions	60	54	8	8.9
5. Restricted range	24	21	6	6.7

of all time to fishes and aquatic habitats in the western United States. This period was followed closely by a very active period of dam building, with concomitant increases in irrigated agriculture, especially since about 1930, when large reclamation projects began providing water to irrigate what is now some 10 million acres of land in the West. The decline in abundance of the native fishes of the mainstream Colorado River is associated closely with construction of these mainstream dams (Minckley and Deacon 1968, Holden and Stalnaker 1975 a, b, Seethaler 1978). Declines in fishes of tributary streams are also occurring and are similarly associated with water manipulations of various kinds that result in dewatering portions of fish habitats. Recently, McNatt (1978) has described the process along the San Pedro River of Arizona. I present some documentation here for similar problems along the Virgin River of Utah, Arizona, and Nevada.

The Virgin River drains southwestern Utah and flows through the northwestern corner of Arizona before joining the Colorado River in Lake Mead, Nevada. A salt spring, LaVerkin Springs, enters the river 180 km upstream from its confluence with Lake Mead, forming the upstream limit of distribution for both the Virgin River roundtail chub, *Gila robusta seminuda*, and the woundfin, *Plagopterus argentissimus*. Both are here listed as endangered and both are presently restricted to the mainstream of the Virgin River below LaVerkin Spring. In addition, the Virgin spinedace, a threatened species, occurs both below and above the springs.

Irrigation diversions have been established along the river since the 1860s. Since at least the early 1900s, the Hurricane Diversion, Washington Diversion, and Mesquite Diversions (Fig. 1) have been capable of diverting essentially the total summer flow of the river at each of these three diversion points. La-

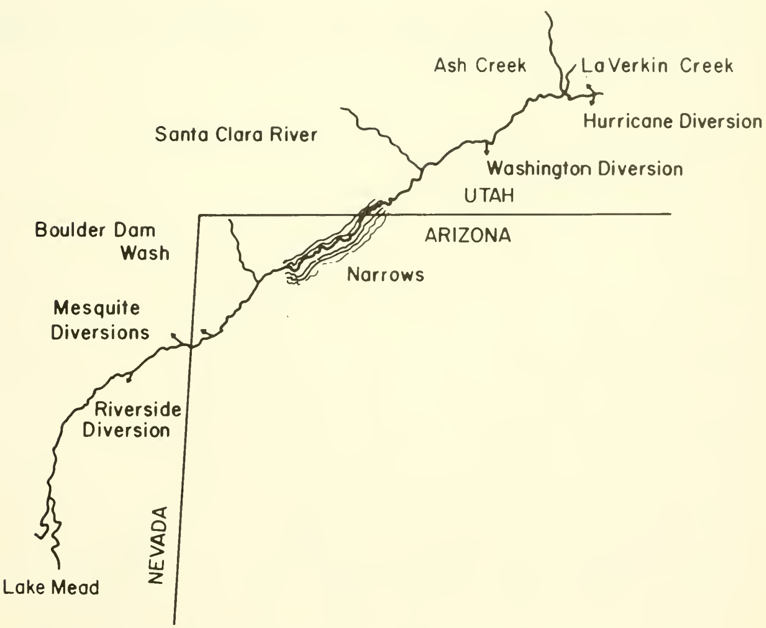

Fig. 1. Mainstream Virgin River below Hurricane diversion showing total remaining potential habitat for the endangered woundfin and roundtail chub, and significant modifications currently restricting their range.

Verkin Springs, entering just below the Hurricane Diversion, plus inflow from LaVerkin and Ash Creeks, maintain permanent stream flow downstream to Washington Diversion (Fig. 1). Littlefield Springs, entering at the lower end of the narrows, maintain permanent streamflow downstream to the Mesquite Diversion (Fig. 1). When the total streamflow is actually used at the above diversion points, only about 52.5 km (or 29 percent) of the remaining 180 km of potential habitat for the two endangered species restricted to the mainstream is actually constantly available to them.

The narrows (Fig. 1) divides the mainstream into an upper and a lower component that appears to effectively isolate the contained fish populations. Elevation and climate in the two regions differ significantly. The difference was reflected by the nearly one-month earlier spawning of the woundfin population in the lower river in the spring of 1977 (Fig. 7).

The question of requirements of these fishes in their remaining habitats has been the subject of studies conducted at various levels of intensity since 1961 (Cross 1975, 78, Williams 1977, Schumann 1978, Peters 1970, Lockhart 1979, Vaughn Hansen Associates 1977). The drought of 1977 resulted in some of the lowest flows on record in the Virgin River, a circumstance which allowed significant insights into the probable effects of water development projects which would tend to reduce or alter flows in the river. The more normal flows of 1978 provided a useful comparison to the low-flow conditions of 1977.

Length-frequency analysis was used as a convenient means of examining the population structure of the fishes in the Virgin River. Samples were taken by repetitively seining an area until the number of fish collected amounted to less than 10 percent of the highest number collected. In this way we insured a good representative sample of all fish occurring in the sampled area. Figure 2 demonstrates that samples taken in August 1977 and more extensive sampling from November 1977 provide essentially the same picture of population structure for woundfin. This suggests that sampling done in both Au-

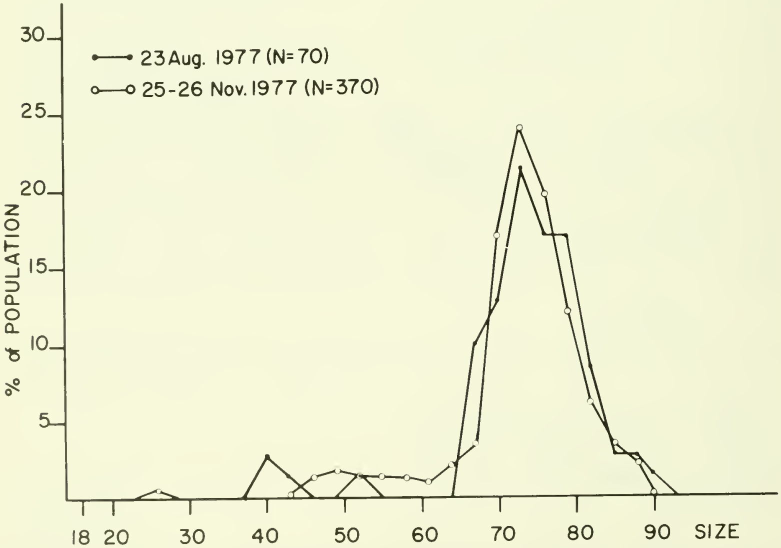

Fig. 2. Length frequency of woundfin in Virgin River above the narrows during fall 1977.

gust and November was extensive enough to provide a good representation of population structure in woundfin. The major fact revealed is that in 1977 young-of-the-year comprised a very small (nearly inconsequential) proportion of the woundfin population above the narrows. By contrast, a comparison of population structure in woundfin above the narrows in 1977 and 1978 (Fig. 3) indicates that young-of-the-year dominated the population in 1978.

When sampling is extensive enough, and stunting can be discounted as a significant factor, much of the information gleaned from an examination of length frequency can be summarized by calculation of a mean length for the population. In this case, for both woundfin and roundtail chub, small mean length indicates relatively high reproductive success and vice versa. Figure 4 and Table 2 present data available on mean length of woundfin above the narrows in 1973, 1977, and 1978, together with a hydrograph of mean monthly flows. They show that in 1973 and 1978, with high winter and spring flows, reproductive success was high, but in 1977, with low flows, reproductive success was low.

A similar situation appears to have existed for the roundtail chub, *Gila robusta seminuda* (Fig. 5, Table 2), except that the species was so rare in 1977 that very few were captured in spite of extensive sampling efforts. This, of course, indicates that not only were environmental conditions in Virgin River during 1977 inimical to successful spawning in this species, they also apparently reduced the survival of adults. Figure 5 does show that the species spawned successfully in at least one location on the upper mainstream of the Virgin River in 1978. Relatively high population density or evidence of a successful hatch was not found at any other location sampled in the upper or lower Virgin River

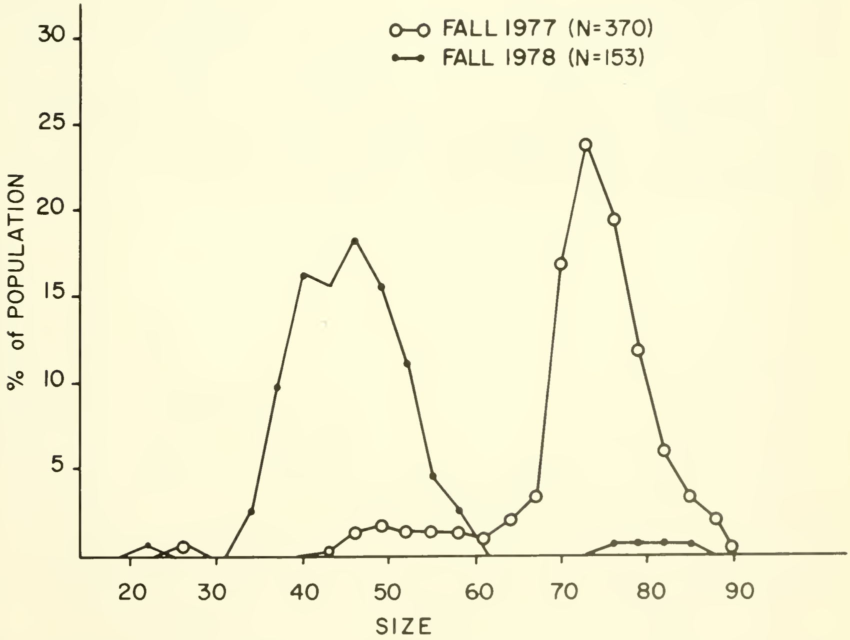

Fig. 3. Comparison of length frequency of woundfin in Virgin River above the narrows in fall 1977 and fall 1978.

TABLE 2. Mean size of woundfin and roundtail chub in Virgin River. The 0 indicates collections were made in the area but no individuals of the species were taken. The – indicates the area was not collected. Data on woundfin from 1973 were provided by Mr. Jerry Lockhart. He probably also took chubs; however, data are not available.

		1973		1977								1978					
		Aug & Sept		1–8 June		23–30 Aug		14–15 Nov		25–26 Nov		12 April		28 Sept		1 Nov	
		X̄	N	X̄	N	X̄	N	X̄	N	X̄	N	X̄	N	X̄	N	X̄	N
Upper river	Woundfin	52.1	60	69.3	172	74.3	70	71.2	416	72.3	371	76.2	190	46.0	153		–
	Chub			158.2	5	173	1		0		1		0	67.6	102		–
Lower river	Woundfin	50.2	105	44.0	177	53.6	202		–	56.6	383	58.2	112	44.4	427	48.6	46
	Chub			45.0	1	173	1		–	158	3		0	84.3	4	70.0	1

in September 1978. Perhaps even in times of "normal" flows there are relatively few optimal habitats for the roundtail chub remaining in the Virgin River.

In addition to the marked differences in reproductive success of woundfin and roundtail chubs in 1977 and 1978, interesting differences in population structures of woundfin above and below the narrows in 1977 were evident. It is apparent from an examination of Figure 6 and Table 2 that young woundfin comprised a far greater proportion of the woundfin population in the lower river in 1977 than was true in the upper river. The effect of the drought on woundfin population structure in the upper river thus appears to have been more severe than was true in the lower river. In the lower river, however, it is apparent that by fall and winter 1977 older or larger fish tended to predominate to a greater extent than was true in either fall 1973 or fall and winter 1978. This suggests (1) that growth of young in 1977 may have been faster than was the case in 1973 and 1978, (2) survivorship may have differentially favored older woundfin during summer 1977, (3) spawning may have occurred earlier in summer 1977 than in 1973 or 1978, or (4) perhaps more probable, the later secondary spawning period was almost entirely unsuccessful in 1977, whereas in 1973 and 1978 it was successful and resulted in a significant contribution to the population in the fall (Fig. 1). The effect of the two spawning periods in 1978 is apparent in Figure 2 as two peaks in the length-frequency diagram in the size range below 60 mm.

Figure 8 shows dates on first appearance of

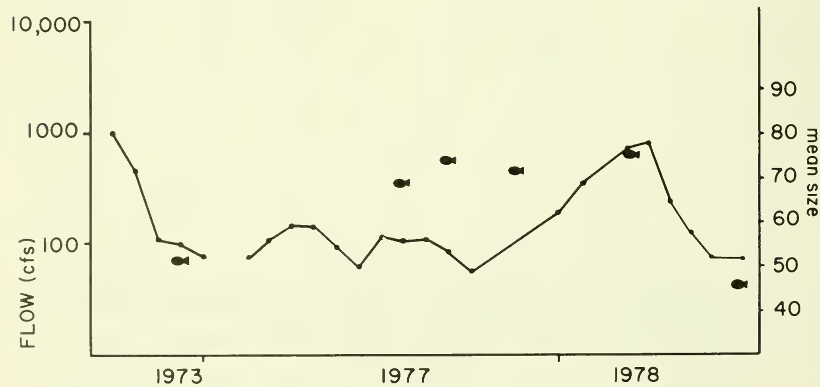

Fig. 4. Mean monthly flow at Hurricane Gage and mean size of woundfin in upper Virgin River 1973, 1977, 1978.

woundfin fry at various locations along the Virgin River during summer 1977. Collections were made at one- to two-week intervals until fry were taken at each location indicated. The uppermost location, indicated by 23 July in Figure 8 was actually below the Hurricane Diversion but above LaVerkin Creek. It is apparent that hatching occurred earlier in the lower river than in the upper river. Furthermore, in the lower river hatching appears to have been delayed by about two weeks at the lowermost station where habitat modification is most obvious.

The earlier appearance of young woundfin in the Arizona segment of the lower river was followed by relatively good survival in 1977 (Fig. 7). By contrast, the later appearance of young woundfin in the upper river was followed by very poor survival in 1977 (Fig. 3). With higher flows in 1978, both upstream and downstream populations of woundfin showed good reproduction, and by fall 1978 the mean size was nearly identical in the two populations (Fig. 6).

Comparisons of hydrographs of Virgin River flows for 1973, 1977, and 1978 show that the major differences in flow occurred during winter and spring. Summer flows suggest a relatively greater degree of similarity for all three years (Vaughn Hansen Associates 1977). If winter and spring flows significantly influence reproductive success of the endangered fishes of the Virgin River, the effect should be discernable in the population structure during the following fall. Figure 9 presents data comparing mean size of woundfin in the fall in both the upstream and downstream populations against mean flows of the river during the spring. Of particular significance is the fact that when stream flow is low, mean size is high and vice versa. Interestingly, Figure 9 also suggests that when mean spring flows are above 700 cfs, reproductive success may be slightly poorer than when mean spring flows are between 400 and 600 cfs. Data are not available for times when mean spring flows fall between 100 and 400 cfs, but at about 100 cfs it is clear

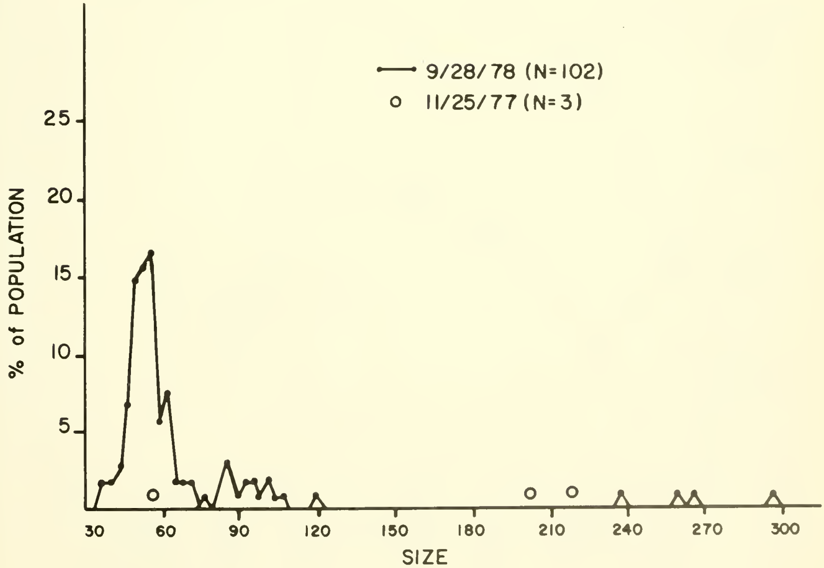

Fig. 5. Length frequency of roundtail chub in Virgin River above the narrows. The o's indicate size of the only three individuals taken in extensive sampling on 25 November 1977.

that reproductive success falls off dramatically. Essentially, the same relationships exist if mean flows from January to June, inclusive, are compared. This examination suggests that reproductive success of woundfin (and roundtail chub) in their only remaining habitat is extremely poor when mean winter and spring flows fall to about 100 cfs.

The drought of 1977, resulting in some of the lowest flows on record in the Virgin River, has permitted a significant insight into the habitat requirements of the endangered native fishes of the river. It is apparent that current utilization practices of the water resources permit survival of the native fishes in about 29 percent of their remaining potential habitat. Intermittent flows coupled with higher summer temperatures throughout the remainder of the potential range (Schumann 1978, Lockhart 1979) make it unreliable as a fish habitat. Within the remaining 29 percent of the potential habitat, reproduction occurs during years of normal flow, but is extremely poor to absent during years of low flow. This circumstance suggests that at present the fishes are living in a habitat which has extremely little potential for further development or alteration without adverse impacts on the endangered species present. Continued monitoring of reproductive success and population structure under varying conditions of stream flow will permit refinement of flow requirements. It is apparent that the roundtail chub is in an even more precarious position than is the woundfin and that both species require higher flows in spring and winter than they do in summer.

Obviously, problems associated with the

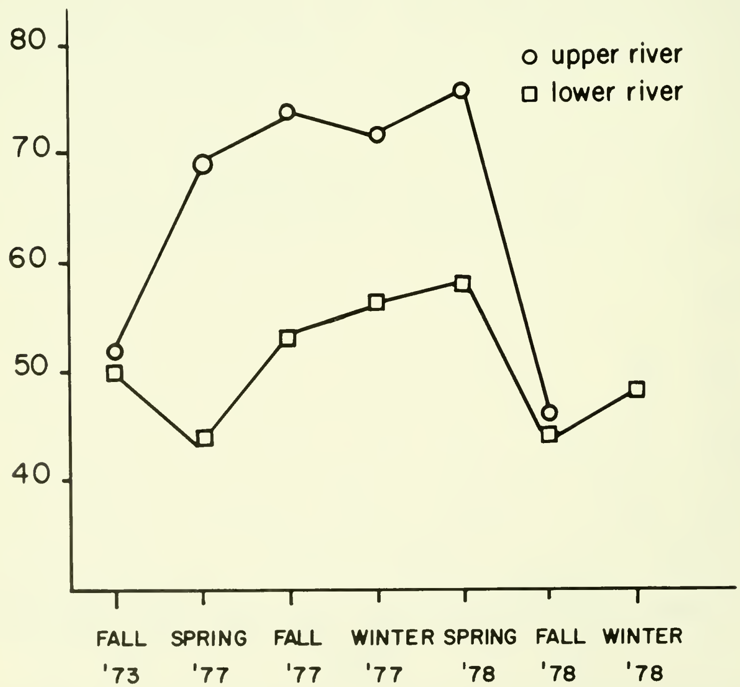

Fig. 6. Comparison of mean size of woundfin in the upper and lower mainstream Virgin River 1973, 1977, 1978.

effects of habitat modifications are complex, often having been developing for more than a century, and always difficult to quantify or even specifically identify. The problems identified and briefly examined here for the Virgin River have numerous counterparts throughout the West, as is obvious from the fact that 97 percent of the western fishes listed herein are on this list in part because of the present or threatened destruction, modification, or curtailment of their habitat or range.

Disease and Parasitism

Wilson et al. (1966) and Seethaler (1978) have suggested that parasitism may place significant stress on western fishes being subjected to other alterations in their environments. Examination of museum specimens of *Crenichthys baileyi* collected since 1938, supplemented by examination of both museum specimens and individuals taken in the field in 1965 and 1966, yields interesting insights into responses to stress. *Crenichthys baileyi* occurs in warm springs along the course of the Pluvial White River of eastern Nevada. During the early 1960s various exotic or nonnative species were established in some *Crenichthys* habitats (Deacon et al. 1964, Hubbs and Deacon 1964).

Figure 10 and Table 3 show the incidence of parasitism by *Lernea* on *Crenichthys baileyi* populations living in Crystal Spring and in the warm headwaters springs of the Moapa River from 1938 to 1966. All available data are presented in Table 3. Only data resulting from an examination of 20 or more individuals are plotted in Figures 10 and 11. During this period no nonnative fish were established in Crystal Spring. The poulation remained abundant and virtually free of parasitism by *Lernea*.

In the headwaters of Moapa River, the

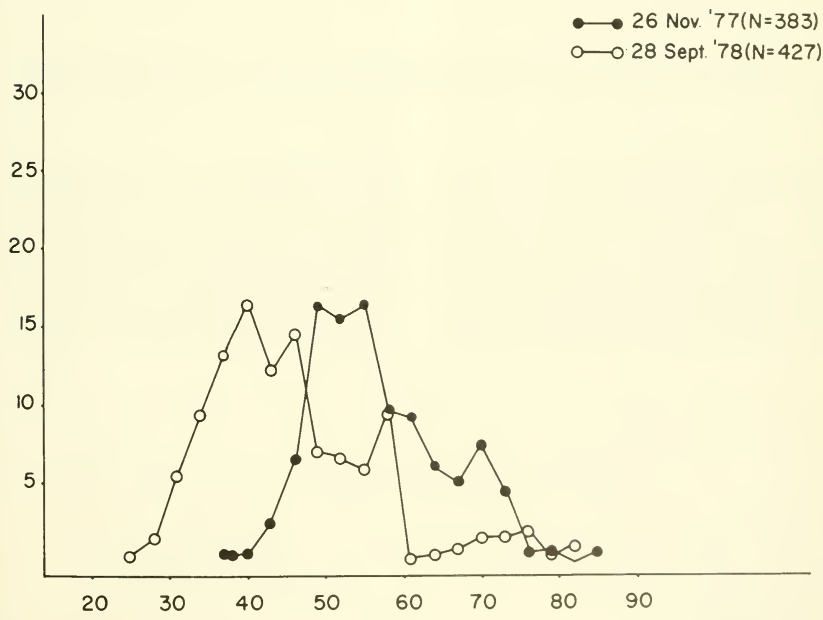

Fig. 7. Length frequency of woundfin in the lower Virgin River, fall 1977 and fall 1978.

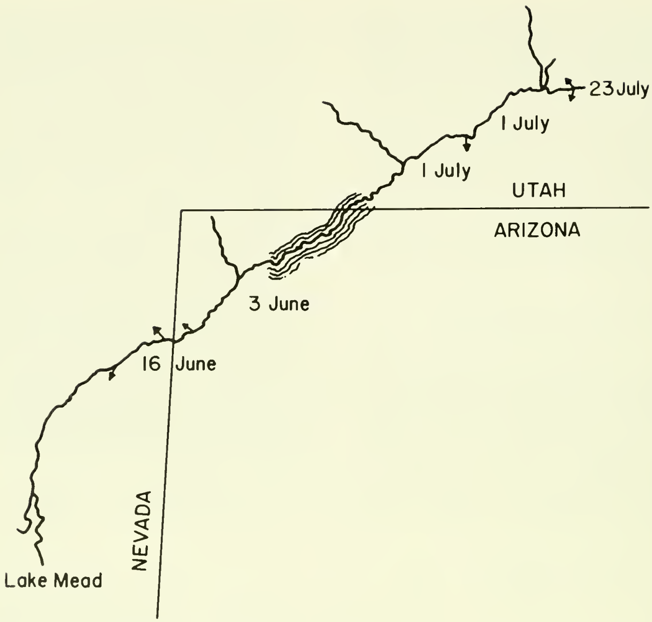

Fig. 8. Dates of the first appearance of woundfin fry at various locations along the mainstream Virgin River during summer 1977. Collections were made at all locations indicated at one- to two-week intervals until fry were taken.

shortfin molly (*Poecilia mexicana*) was introduced in the spring of 1963 (local testimony). No mollies were taken in collections made in March 1963, but they were present in collections made on 12 October 1963 (Deacon et al. 1964). In addition, the mosquitofish (*Gambusia affinis*) had been present in the area since before 1938 (Miller and Alcorn 1946). While collections of *C. baileyi* made during 1963 showed an increased incidence of parasitism by *Lernea*, the fish population remained abundant and the incidence of parasitism declined (Fig. 10). In addition, there was a 5 percent incidence of parasitism in 1959 prior to introduction of mollies. Perhaps the several spring sources in the head-

TABLE 3. Incidence of parasitism by *Lernea* on *Crenichthys baileyi*. N = number examined. % = percent with one or more *Learnea* attached.

	1938		1940		1941		1947		1948		1949		1950	
Location	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Headwaters of Moapa River	250	0	7	0	27	0	28	0	158	0	11	0	11	0
Ash Spring	5	0	8	0					106	0	64	0		
Crystal Spring									20	0	64	0	83	0
Hiko Spring	1576	0	6	0					54	0	52	0		
Mormon Spring														
Preston Town Spring													58	0
Preston Big Spring													17	0

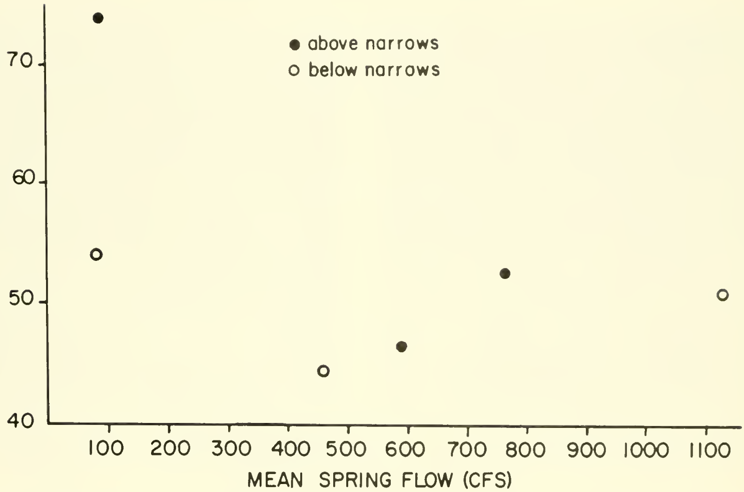

Fig. 9. Mean spring flows in Virgin River related to mean size of woundfin in the following fall. Data are from 1973, 1977, 1978. Mean spring flow is the average of the monthly means for April, May, and June.

waters were invaded by mollies at different times; in any case, the *Crenichthys* population did not appear to either sustain or reflect any permanent damage from parasitism.

Other populations for which historical data are not so extensive but which, through 1966, were not subjected to stress from nonnative fishes occur at Mormon Spring and Preston Big Spring (Table 3). In addition, while guppies *Poecilia reticulata* have been in Preston Town Spring since sometime before 1961 (Deacon et al. 1964), we have seen no indication of parasitism by *Lernea* (Table 3). Of course, the population was not examined immediately after introduction of *Poecilia*.

Figure 11 illustrates changes in incidence of parasitism by *Lernea* for populations which became rare or extinct. In Ash Spring, mosquitofish were not present in 1946 (Miller and Alcorn 1946) but were present in 1959 (Miller and Hubbs 1960). In March 1963, *Poecilia* was not present, but *P. latipinna*, *P. mexicana*, and *Cichlasoma nigrofasciatum* were present and breeding on 3 June 1964. They have since remained abundant in Ash Spring and its warm outflow stream. Incidence of parasitism by *Lernea* on *C. baileyi* was significant for the first timme in 1964 and remained so in 1965. The *C. baileyi* population in this limnocrene declined in abundance and remains extremely rare today. The increase in parasitism closely followed introduction of the exotics and was followed by a dramatic decline in abundance of the na-

TABLE 3 continued.

1951		1954		1959		1960		1961		1962		1963		1964		1965		1966	
N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
		19	0	920	5.1			11	9.1	68	0	238	14	15	0	1259	0	253	0
														90	10	224	9	5	0
110	0	11	0			4	0	16	25	16	0					2828	.04	356	0
		101	0			82	0							69	0	313	20	27	59
														159	0	1051	0	188	0
								25	0					5	0	25	0		
117	0							17	0					20	0	704	0	440	0

tive fish population.

At Hiko Spring, no parasitism was evident until 1965 (Fig. 11). Shortfin mollies (*P. mexicana*), mosquitofish, and largemouth bass were all absent from collections made at Hiko Springs in June 1964. In January 1965 a few mosquitofish were seen and one was collected. In February 1965 both shortfin mollies and largemouth bass were seen in the limnocrene, and in March mollies began to appear in the monthly collections. Both mollies and mosquitofish increased in abundance through 1965. *Lernea* first appeared on *Crenichthys* in March 1965. Incidence of parasitism increased to February 1966, at which time examination of the population was discontinued because numbers had declined too low to permit continuation of the study. The population was extinct before June 1967.

Biotic Interactions

Interactions of native western fishes with introduced species have resulted in extensive hybridization, especially in trout, plus various kinds of competitive and predatory consequences. One example which is especially interesting, because it was replicated, occurred in Manse Spring, Pahrump Valley, Nye Co., Nevada. The endemic, and currently endangered, Pahrump killifish (*Empetrichthys latos latos*) was restricted to the single limnocrene which was approximately triangular with maximum dimensions of about 25 × 15 m. In November 1961 six goldfish were introduced into the spring by one of the farmhands. They had reproduced by July 1962 and during that summer the children on the farm removed most of the

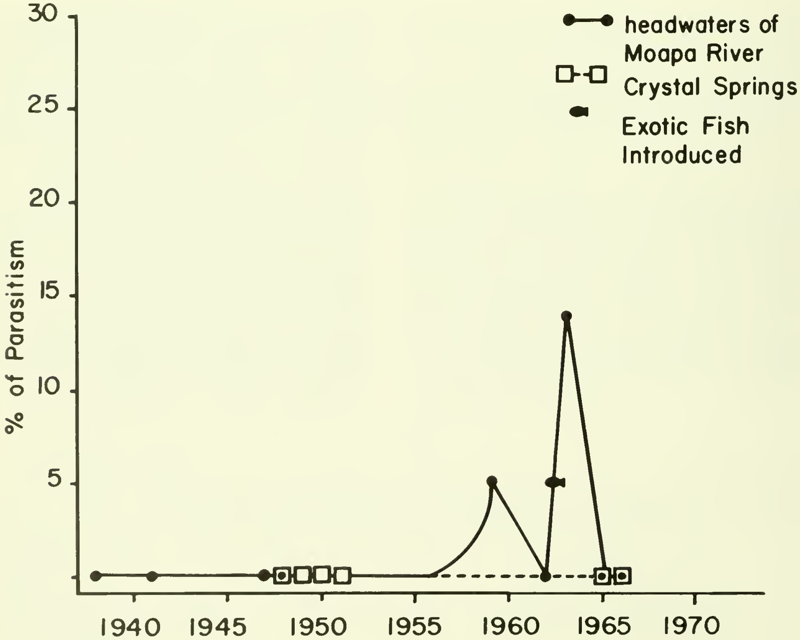

Fig. 10. Incidence of parasitism by *Lernea* on *Crenichthys baileyi* populations which remained abundant.

submerged aquatic vegetation from the pond to make a better swimming pool (Deacon et al. 1964). The killifish population crashed during the winter of 1962–63 to almost certainly fewer than 50 individuals (Fig. 12). The population had recovered somewhat by winter 1963 but appeared to be less abundant through early 1965 than was the case prior to introduction of goldfish.

In July 1967, Professors Carl L. Hubbs and R. R. Miller and I, in cooperation with our families and several students from UNLV and ASU, attempted to remove all goldfish from Manse Spring by trapping, seining, using anesthetic, and, finally, dynamiting. All killifish captured were held in cages in a nearby small spring and all goldfish were destroyed. A total of 1239 killifish were captured and returned. At least two adult goldfish eluded us and spawned by the end of the summer. The killifish population crashed as it had in 1963, reaching a low point of probably fewer

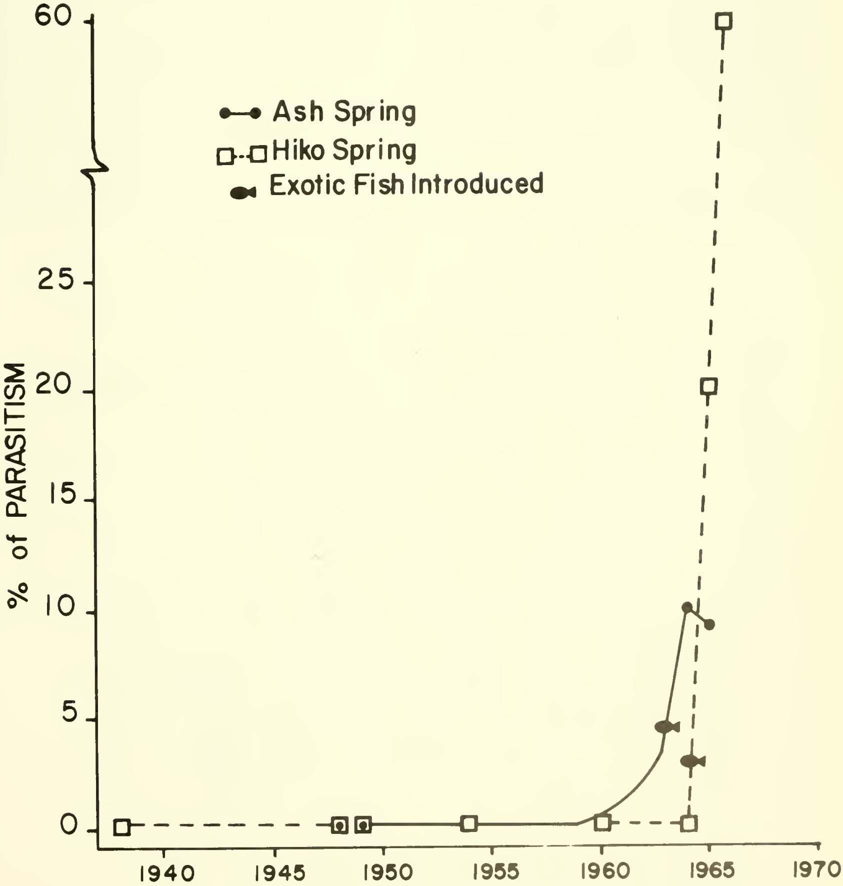

Fig. 11. Incidence of parasitism by *Lernea* on *Crenichthys baileyi* populations which became rare or extinct.

than 50 individuals in July 1968. This low population size persisted through January 1969 (Fig. 12), but by August 1971, when a transplant was made into Corn Creek Spring, the population had recovered significantly. In August 1975, Manse Spring failed as a result of excessive pumping of groundwater in the area (Soltz and Naiman 1978).

Prior to making the killifish transplant into Corn Creek Spring the population of introduced largemouth bass and mosquitofish (*Gambusia affinis*) was removed. A few mosquitofish escaped the final poisoning efforts in Corn Creek Spring, but by November 1973 the original stocking of 29 killifish had built a population of about 1300. In addition, mosquitofish had become extremely abundant. By November 1974 approximately 250 killifish were estimated to occur in Corn Creek Spring. The population had not increased by July 1975. In April 1976, 165 killifish were removed from the spring and it was poisoned in a second effort to remove mosquitofish. The effort was successful and killifish had built an estimated population of 2000 fish by November 1976 and 2500 by October 1977.

These data show that on two occasions in Manse Spring a population increase of goldfish was accompanied by a marked population decline of Pahrump killfish, and on one occasion in Corn Creek Spring a population increase of mosquitofish was accompanied by a killifish population decline. A cause-effect relationship is strongly suggested, perhaps relating to competitive interactions of the young or predation.

Restricted Range

While many western fishes have extremely restricted ranges, none is so restricted or isolated as the Devils Hole pupfish, *Cyprinodon diabolis*. A discussion of the biology of this species and description of its habitat are presented by Soltz and Naiman (1978). Deacon

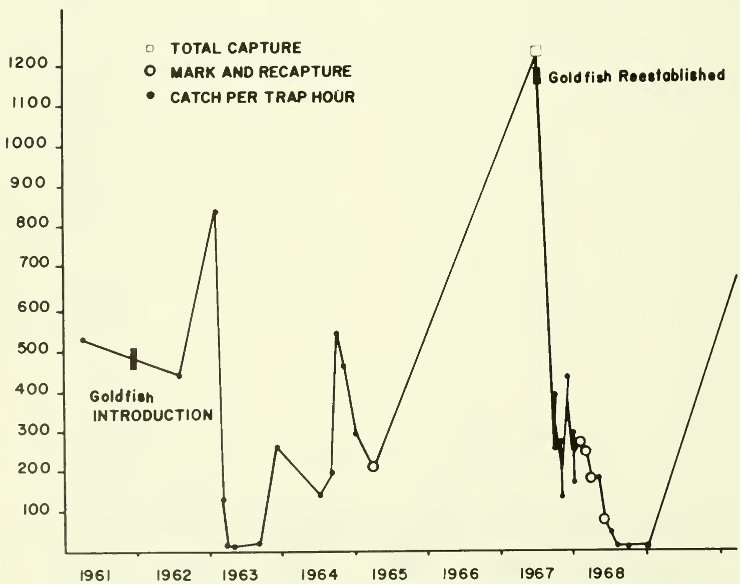

Fig. 12. Changes in population size of Pahrump killifish 1961–1968.

and Deacon (1979) provide a detailed description of fluctuations in population size and probable causes for these fluctuations through December 1976. Data on fluctuations in population size presented here extend through December 1978 (Fig. 13, Table 4). Figure 13 illustrates the direct and marked influence of relatively small changes in water level in Devils Hole on minimum population size of *Cyprinodon diabolis*. The water levels indicated in Figure 13 refer to a reference point established by USGS above the maximum water level. Therefore, depth of water in the habitat increases as the distance below the reference point (in feet) decreases. In addition, the water level shown is actually the minimum level permitted by the courts during the time indicated. The first level indicated (3.9) represents the lowest water level reached prior to intervention of the courts. Water levels normally fluctuated somewhat above the level indicated, but almost never below that level. Generally, water levels were highest in winter and very near the permissible minimum during the summer irrigation season. This, of course, reflects the fact that the water level in Devils Hole is directly and rapidly influenced by pumping of groundwater nearby.

The somewhat erratic population fluctuations in 1972 and 1973 reflect responses to temporary management attempts as well as to scouring floods which occurred during this period (Deacon and Deacon 1979). Once

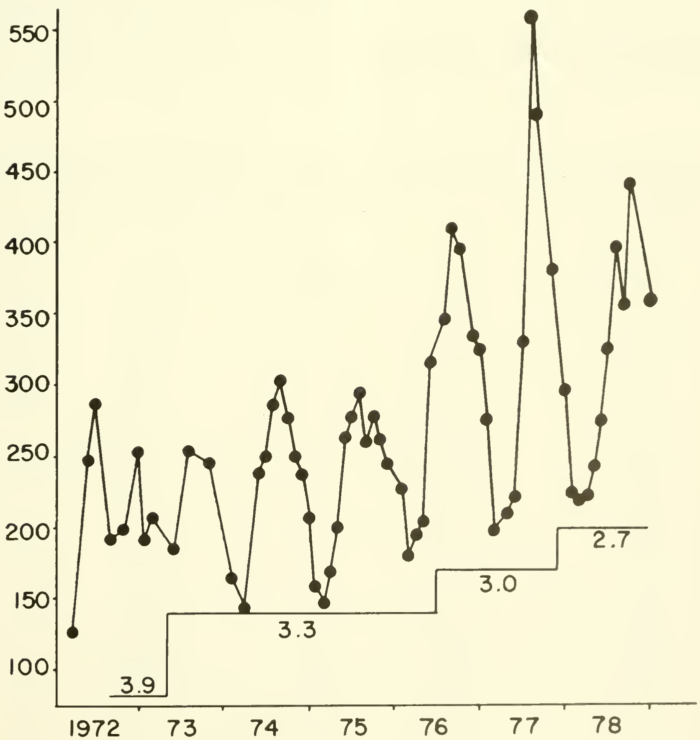

Fig. 13. Devils Hole pupfish population size compared to minimum water levels 1972–1978.

some stability was achieved in water levels, it became possible to attempt management of water level to achieve a desired minimum annual population size. The desired minimum population size was established at 200 in an effort to insure that the population would not fall so low as to tend to accelerate toward extinction. The present court-mandated level of 2.7 appears to be just maintaining minimum population size (Fig. 13, Table 4).

This example illustrates the direct and rapid impact on restricted native fishes which can result from even modest developments nearby. Often, as was true in this case, the developer may be almost entirely unaware of the consequences of his activities. For fishes living in restricted environments, this lack of awareness can mean extinction.

DISCUSSION

It is apparent that the full variety of reasons for becoming threatened are exemplified among the endangered or threatened fishes of the West. The legitimate question arising from this and every consideration of endangered species is "Why bother? What good are they?" The answers to those questions, I believe, must include at least two parts: (1) because it is to our own self-interest to do so, and (2) because our society's values, as expressed through federal law, require us to "bother." The second answer has been and will continue to be debated and perhaps modified. The first is really the core of the endangered species debate. The argument, simplified, I believe, involves at least the following considerations. Because populations are dependent upon and interact within ecosystems, extinction is an indication of a significant change in the ecosystem—in general, a reduced capability to support life or at least to support diversity. The fact that an endangered species is involved may, therefore, be an indication that the long-term carrying capacity of an ecosystem may be exceeded (the

TABLE 4. Estimated population size of the Devils Hole pupfish (*Cyprinodon diabolis*) in Devils Hole, Nye County, Nevada, 1972–1978. Estimates are the maximum number of fish actually counted visually during standardized attempts at counting the entire population. Data prior to 4 June 1974 were taken by Dr. R. R. Miller and subsequently by J. E. Deacon.

Date	Population estimate	Date	Population estimate	Date	Population estimate
1972		1975		1977	
6 April	127	22 Jan	208	20 Jan	324
2 June	248	20 Feb	159	24 Feb	276
28 July	286	18 Mar	148	24 Mar	198
27 Sept	191	10 Apr	158	5 May	210
14 Nov	199	19 May	201	6 June	221
		16 June	262	27 June	359
1973		30 July	278	11 July	330
10 Jan	252	20 Aug	294	15 Aug	553
20 Feb	191	30 Sept	260	26 Sept	490
28 Mar	208	21 Oct	279	28 Nov	381
12 June	184	25 Nov	261		
30 Aug	253	16 Dec	246	1978	
6 Nov	244			16 Jan	296
		1976		2 Mar	225
1974		17 Feb	228	16 Mar	219
5 Feb	163	3 Mar	180	24 Apr	223
29 Apr	143	30 Mar	181	19 May	242
5 June	239	27 Apr	195	19 June	274
11 July	250	18 May	203	20 July	326
22 Aug	286	22 June	316	11 Aug	388
15 Sept	302	2 Aug	345	13 Sept	358
9 Oct	277	24 Sept	410	18 Oct	441
19 Nov	250	18 Oct	385	11 Dec	361
18 Dec	238	3 Dec	334		

argument of the canary in the coal mine). Thus, it follows that if we are concerned about the ability of our children to function in the ecosystem in a manner at all comparable with our present functioning, it may be important to maximize the survival of species other than *Homo sapiens* who are also dependent on that ecosystem.

Another major line of argument is the diversity-stability one (i.e., there appears to be a tendency for more diverse ecosystems to be more stable). Because more stable ecosystems tend to permit coping with times of poor productivity, it seems that enlightened self-interest would dictate that we make efforts to promote stability. Another cogent part of this argument is the inverse relationship between diversity and energy flow (in molecular systems, ecological systems, and in organization of cities) described by Watt (1972, 1973). He pointed out that the principle appears to be true in societal organization to the extent that in the U.S. we find fewer book titles per capita than less industrialized societies, as well as declining numbers of automobile and airplane manufacturers, increasingly standardized foods in supermarkets and restaurants, symphony orchestras almost restricting performances to the work of eight men, difficulties with publishing innovative books or trying out innovative ideas, and declining numbers of species (Watt 1972, 1973). In some ill-defined way this general reduction in environmental diversity seems to result in a search for replacement of the satisfaction or sensory stimulation which it provided. Thus, we have significant and expanding elements in our society attempting to satisfy their senses through membership in cults, sexual experimentation, use of drugs and alcohol, etc. Basically, it seems that as we manufacture a more "efficient" society we increase its energy flow while reducing its diversity. This seems to result in a search for diversity by the members of society. Perhaps the most dramatic demonstration that environmental stimulation derived from experiences with or in nature is *essential* to modern man's feeling of well-being comes from the successes realized in the treatment of "hopeless" mental cases (Iltis 1967). Dramatic improvements resulted from taking these people on camping trips. Many people obviously have experienced the tremendous release of tension that can be felt when you "get away from it all," or, to put it another way, when you have an opportunity to become acquainted with the diversity and sensory stimulation available in nature. Finally, the availability of genetic diversity in plants and animals as a basis for producing new or better crops, medicines, and pharmaceuticals (Reisner 1978) has been emphasized as one of the most compelling arguments for saving species.

Thus, there are a number of biological reasons to justify saving endangered species. These usually have implications that extend to other areas of human endeavor. If man's uniqueness in fact is his knowledge of his world, if *Homo sapiens* is the knowing one, then each extinction diminishes man's capacity of know—and to that extent man's humanity. It seems to me that the Endangered Species Act represents a society saying "This is as far as we will go." The necessity of making such a statement will always be questioned, but it does represent an attempt at insuring that our children on into many generations will have available to them some of the humanizing experiences that were available to us.

Perhaps we have taken the position that the extermination must stop because of our general awareness that there is no other choice. Human civilization has always had a very nomadic character about it. The dominant center of Western civilization has shifted from the fertile crescent of Mesopotamia to Egypt, Greece, Rome, Europe, Great Britain, and the United States as environmental overexploitation has forced (or permitted) these nomadic wanderings. With the entire planet occupied by civilized societies, there is no way to continue the wanderings of civilization. The last remnant of the tendency appears to be exportation of the environmental degradation required to support the kind of society we have created. Thus, no longer does our civilization have its primary impact confined to national boundaries. We find ourselves responsible for destruction of tropical rain forests, whales, pupfish, woundfin, and any number of other worldwide resources, both renewable and nonrenewable. A balance of payments deficit

is clearly one serious and unacceptable consequence, but it is completely overshadowed by the rapid diminution of the world's ability to support the biotic diversity so essential to man's physical and mental well-being.

During this symposium Lovejoy (1979) has provided a frightening description of the awful magnitude of the problem. Clements (1979) has clearly shown that it is our own society, not societies in the under-developed countries of the tropics, that must be held primarily responsible for such all-pervasive, worldwide environmental degradation. Perhaps an understanding of these important facts will hasten the hard decisions which must be made to apply the principles of the Endangered Species Act on a worldwide scale. Spencer (1979) provided extensive documentation to show that the very difficult and costly decisions essential to slowing the rate of environmental degradation in the United States are being made in some specific cases. His presentation is perhaps the most encouraging evidence presented at the symposium to indicate that there are forces at work in our society which have a slim possibility of forcing the significant shifts in societal values which Clements (1979) described as essential if we are to prevent the collapse of our system.

The answers to "Why save species?" are many-faceted, almost always translate into "Why save ecosystems?" and clearly demand searching examination of human values. It seems particularly powerful, therefore, to find philosophers, theologians, and ecologists converging on essentially the same answers to these questions. Though ecologists tend to understandably emphasize species and ecosystems and theologians tend to emphasize individuals and anthropocentricity, pretty much the same conclusions emerge. The most succinct and, to the Christian world, probably the most widely understandable conclusion we can arrive at was expressed by Professor Hugh Nibley. In a 1978 essay examining man's relationship with his environment he said, "Man's dominion is a call to service, not a license to exterminate."

ACKNOWLEDGMENTS

Numerous people have assisted in the development of data and ideas presented herein. To all I express sincere gratitude. James D. Williams, Gail Kobetich, Thom Hardy, and the American Fisheries Society Endangered Species Committee were instrumental in development of Tables 5 and 6. Jerry

TABLE 5. Described taxa of threatened freshwater fishes of western North America: 1979.

Common name	Scientific name	Status	Present* threat	Historical distribution
Trouts, family Salmonidae				
Little Kern golden trout	*Salmo aquabonita whitei* Jordan	T	1,4	CA
Arizona trout	*Salmo apache* Miller 1972	T	1,4	AZ
Lahontan cutthroat trout	*Salmo clarki henshawi* Gill and Jordan	T	1,4	CA,NV,UT,WA
Colorado River cutthroat trout	*Salmo clarki pleuriticus* Cope	SC	1,4	CO,UT,WY
Paiute cutthroat trout	*Salmo clarki seleniris* Snyder	T	1	CA
Greenback cutthroat trout	*Salmo clarki stomias* Cope	T	1,4	CO
Utah cutthroat trout	*Salmo clarki utah* Suckley	T	1,4	UT,WY,NV
Rio Grande cutthroat trout	*Salmo clarki virginalis* (Girard)	SC	1,4	CO,NM
Gila trout	*Salmo gilae* Miller	T	1	NM,AZ
Sunapee trout	*Salvelinus alpinus aureolus* Bean	T	4	ME,NH,ID
Montana Arctic grayling (stream form)	*Thymallus arcticus montanus* (Pallas)	T	1	MT
Mudminnows, family Umbridae				
Olympic mudminnow	*Novumbra hubbsi* Schultz	SC	1	WA

Minnows, family Cyprinidae				
Mexican stoneroller	*Campostoma ornatum* Girard	SC	1,3	AZ,TX,(Mexico)
Devils River minnow	*Dionda diaboli* Hubbs and Brown	T	1	TX
Desert dace	*Eremichthys acros* Hubbs and Miller	T	1,5	NV
Alvord chub	*Gila alvordensis* Hubbs and Miller 1972	SC	1	NV,OR
Fish Creek Springs Tui chub	*Gila bicolor euchila* Hubbs and Miller 1972	E	1,4,5	NV
Independence Valley Tui chub	*Gila bicolor isolata* Hubbs and Miller 1972	T	1,4,5	NV
Mohave Tui chub	*Gila bicolor mohavensis* (Snyder)	E	1,4	CA
Newark Valley Tui chub	*Gila bicolor newarkensis* Hubbs and Miller 1972	SC	1,5	NV
Oregon Lakes Tui chub	*Gila bicolor oregonensis* (Snyder)	SC	1	OR
Lahontan Tui chub	*Gila bicolor obesa* (Girard)	SC	1	NV
Owens Tui chub	*Gila bicolor snyderi* Miller 1973	E	1,4,5	CA
Thicktail chub	*Gila crassicauda* (Baird and Girard)	E	1	CA
Humpback chub	*Gila cypha* Miller	E	1	AZ,CO,UT,WY
Bonytail	*Gila elegans* Baird and Girard	E	1,4	AZ,CA,CO,NV,UT,WY
Gila chub	*Gila intermedia* (Girard)	SC	1,4	AZ,NM
Chihuahua chub	*Gila nigrescens* (Girard)	E	1,4	NM,Mexico (Ch)
Yaqui chub	*Gila purpurea* (Girard)	E	1,4	AZ,Mexico (So)
Gila roundtail chub	*Gila robusta grahami* Baird and Girard	T	1,4	AZ,NM
Pahranagat roundtail chub	*Gila robusta jordani* Tanner	E	1,4	NV
Virgin River roundtail chub	*Gila robusta seminuda* Cope	E	1	AZ,NV,UT
Oregon chub	*Hybopsis crameri* Snyder	SC	1,4	OR
Least chub	*Iotichthys phlegethontis* (Cope)	T	1,4	UT
White River spinedace	*Lepidomeda albivallis* Miller and Hubbs	T	1,4	NV
Virgin spinedace	*Lepidomeda mollispinis mollispinis* Miller and Hubbs	T	1,4	AZ,UT
Big Spring spinedace	*Lepidomeda mollispinis pratensis* Miller and Hubbs	E	1,4,5	NV
Little Colorado spinedace	*Lepidomeda vittata* Cope	SC	1	AZ
Spikedace	*Meda fulgida* Girard	T	1,4	AZ,NM
Moapa dace	*Moapa coriacea* Hubbs and Miller	E	1,3,4,5	NV
Yaqui Beautiful shiner	*Notropis formosus mearnsi* Snyder	SC	1	AZ (Mexico)
Rio Grande shiner	*Notropis jemezanus* (Cope)	SC	1,4	NM
Proserpine shiner	*Notropis porserpinus* (Girard)	T	1	TX
Bluntnose shiner	*Notropis simus* (Cope)	E	1,4	NM,TX
Woundfin	*Plagopterus argentissimus* Cope	E	1	AZ,NV,UT
Splittail	*Pogonichthys macrolepidotus* (Ayres)	SC	1	CA
Colorado squawfish	*Ptychocheilus lucius* Girard	E	1,3,4	AZ,CO,UT,CA,NM,NV,WY
Relict dace	*Relictus solitarius* Hubbs and Miller 1972	SC	1	NV

Independence Valley speckled dace	*Rhinichthys osculus lethoporus* Hubbs and Miller 1972	E	1,4,5	NV
Ash Meadows speckled dace	*Rhinichthys osculus nevadensis* Gilbert	E	1,4	NV
Clover Valley speckled dace	*Rhinichthys osculus oligoporus* Hubbs and Miller 1972	E	1,4,5	NV
Kendall Warm Springs dace	*Rhinichythys osculus thermalis* Hubbs and Kuehne	SC	5	WY
Moapa speckled dace	*Rhinichthys osculus moapae* Williams 1978	T	1,3,4	NV
Loach minnow	*Tiaroga cobitis* Girard	SC	1,4	AZ,NM
Suckers, family Catostomidae				
Yaqui sucker	*Catostomus bernardini* Girard	SC	1	AZ (Mexico)
White River desert sucker	*Catostomus clarki intermedius* (Tanner)	T	1	NV
Webug sucker	*Catostomus fecundus* Cope and Yarrow	SC	1,4	UT
Zuni bluehead sucker	*Castostomus dicobolus yarrowi* Cope	T	1 c3fu	NM
Lost River sucker	*Catostomus luxatus* (Cope)	SC	1,4	CA,OR
Modoc sucker	*Castostomus microps* Rutter	E	1,4	CA
Warner sucker	*Catostomus warnerensis* Snyder	E	1,4	OR
Shortnose sucker	*Chasmistes brevirostris* Cope	T	1,4	CA,OR
Cui-ui	*Chasmistes cujus* Cope	E	1	NV
June sucker	*Chasmistes liorus* Jordan	SC	1,4	UT
Razorback sucker	*Xyrauchen texanus* (Abbott)	T	1,4	AZ,CA,CO,NV,UT,WY
Freshwater catfishes, family Ictaluridae				
Yaqui catfish	*Ictalurus pricei* (Rutter)	SC	1	AZ (Mexico)
Widemouth blindcat	*Satan eurystomus* Hubbs and Bailey	T	1	TX
Toothless blindcat	*Trogloglanis pattersoni* Eigenmann	T	1	TX
Killifishes, family Cyprinodontidae				
Railroad Valley springfish	*Crenichthys nevadae* Hubbs	SC	1	NV
Leon Springs pupfish	*Cyprinodon bovinus* Baird and Girard	T	1,4,5	TX
Devils Hole pupfish	*Cyprinidon diabolis* Wales	E	1,5	NV
Comanche Springs pupfish	*Cyprinodon elegans* Baird and Girard	E	1	TX
Gila desert pupfish	*Cyprinodon macularius macularius* Baird and Girard	T	1,4	AZ, Mexico
Valley Amargosa pupfish	*Cyprinodon nevadensis amargosae* Miller	SC	1,4	CA
Ash Meadows Amargosa pupfish	*Cyprinodon nevadensis mionectes* Miller	T	1,4	NV
Warm Springs Amargosa pupfish	*Cyprinodon nevadensis pectoralis* Miller	E	1,4,5	NV
Owens pupfish	*Cyprinodon radiosus* Miller	E	1,4	CA
White Sands pupfish	*Cyprinodon tularosa* Miller and Echelle 1975	SC	1,4,5	NM

Pahrump killifish	*Empetrichthys latos latos* Miller	E	1,4,5	NV
Livebearers, family Poecilidae				
Amistad gambusia	*Gambusia amistadensis* Peden 1973	E	1,5	TX
Big Bend gambusia	*Gambusia gaigei* Hubbs	E	1,5	TX
San Marcos gambusia	*Gambusia georgei* Hubbs and Peden	E	1,4,5	TX
Clear Creek gambusia	*Gambusia heterochir* Hubbs	T	4	TX
Pecos gambusia	*Gambusia nobilis* (Baird and Girard)	SC	1,4	TX,NM
Gila topminnow	*Poeciliopsis occidentalis* (Baird and Girard)	E	1	AZ,NM
Sticklebacks, family Gasterosteidae				
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni* Girard	E	1,4	CA
Sunfishes, family Centrarchidae				
Guadalupe bass	*Micropterus treculi* (Vaillant and Bocourt)	SC	1	TX
Perches, family Percidae				
Fountain darter	*Etheostoma fonticola* (Jordan and Gilbert)	E	1,5	TX
Gobies, family Gobiidae				
O'opu nakea	*Awaous stamineus* (Eydoux and Souleyet)	SC	1,4	HI
Tidewater goby	*Eucyclogobius newberryi* (Girard)	SC	1	CA
O'opu alamo'o	*Lentipes concolor* (Gill)	T	1	HI
O'opu nopili	*Sicydium stimpsoni* Gill	SC	1,4	HI
Sculpins, family Cottidae				
Rough sculpin	*Cottus asperrimus* Rutter	SC	1	CA
Utah Lake sculpin	*Cottus echinatus* Bailey and Bond	E	1,4	UT
Shoshone sculpin	*Cottus greenei* (Gilbert and Culver)	SC	1	ID

*1—Present or threatened destruction of habitat
2—Overutilization
3—Disease
4—Hybridization, competition, exotic or translocated
5—Restricted natural range

Lockhart provided data on woundfin from 1973. Brian Wilson assisted greatly with development of data on parasitism, which could not have been accumulated without accessibility to fish collections at the University of Michigan Museum of Zoology (R. R. Miller), the University of Nevada—Reno (Ira LaRivers), and BYU (Dave White). Encouragement and approval of permits necessary to the work has been provided by the Nevada, Utah, and Arizona Game and Fish departments. Stimulating discussions and searching examination of values have been provided by my family (Maxine, Dave, and Jack and Cindy Williams) and by classes at UNLV. Financial assistance for various aspects of work reported herein has been provided by the U.S. Fish and Wildlife Service, National Park Service, National Science Foundation, Sport Fishing Institute, U.S. Bureau of Reclamation, University of Nevada—Las Vegas, and the City of St. George, Utah, through Vaughn Hansen Associates.

QUESTIONS FOR DR. DEACON

Q. Once a species is on its way to recovery, how does one determine what the population level or population density would be for the species to be considered no longer in danger?

A. That is an extremely knotty problem. In the case of the Devils Hole pupfish we were primarily concerned with maintaining a large enough population to prevent population instabilities that might tend to accelerate the process of extinction. It is generally understood that populations have a minimum size below which they are unlikely to maintain viability. Bob Miller at the University of Michigan did some experimental rearing of other species of pupfish in the 1940s and also performed a number of transplants into springs devoid of fish. His work indicated that experimental populations started with small numbers of individuals tended to decline in abundance after a few generations, sometimes to extinction. His numerous transplants of pupfish into other natural waters were never successful if fewer than 200 individuals were transplanted, and in only two instances were they successful when more than 200 individuals were transplanted. During the middle 1960s a graduate student of mine, Carol James (now Ivy), did some work on the Devils Hole pupfish which, in retrospect, indicated that its population had probably never fallen below 200 individuals. Finally a transplant of 24 Devils Hole pupfish into an artificial pond below Hoover Dam resulted in a population maximum of about 200 individuals, followed by a decline to about 50 individuals. This pattern suggested loss of viability may be occurring in the transplanted population of Devils Hole pupfish. This line of argument was successful in establishing the fact that it would be unacceptably dangerous to permit the population of Devils Hole pupfish to fall below 200 individuals. Once that point was established it was not difficult to show, with four or five years of monthly data on estimated population size, that a water level of 2.7 was necessary to sustain a population of no fewer than 200 individuals. These ecological relationships are being reported in the symposium volume on research in the national parks to be published in 1979.

Q. At what level do you consider the population to not be threatened?

TABLE 6. Undescribed taxa of threatened freshwater fishes of western North America: 1979.

Common name	Scientific name	Status	Present* threat	Historical distribution
Trouts, family Salmonidae				
Alvord cutthroat trout	*Salmo clarki* ssp.	SC	1	OR
Humboldt cutthroat trout	*Salmo clarki* ssp.	SC	1	NV
Redband trout	*Salmo* sp.	SC	1,4	CA,OR,ID,NV
Minnows, family Cyprinidae				
Catlow Tui chub	*Gila bicolor* ssp.	SC	1	OR
Sheldon Tui chub	*Gila bicolor* ssp.	SC	5	NV
Cowhead Lake Tui chub	*Gila bicolor* ssp.	SC	1	CA
Hutton Spring Tui chub	*Gila bicolor* ssp.	T	1	OR
Borax Lake chub	*Gila* sp.	T	1,5	OR
Foskett Spring speckled dace	*Rhinichthys osculus* ssp.	T	1,5	OR
Killifishes, family Cyprinodontidae				
Preston White River springfish	*Crenichthys baileyi* ssp.	T	4,5	NV
Southern White River springfish	*Crenichthys baileyi* ssp.	T	1,3,4	NV
Warm Springs White River springfish	*Crenichthys baileyi* ssp.	SC	1,4,5	NV
Devils River Conchos pupfish	*Cyprinodon eximius* ssp.	T	1	TX
LeConte desert pupfish	*Cyprinodon macularius* ssp.	E	1,4	CA
Quitobaquito desert pupfish	*Cyprinodon macularius* ssp.	SC	1,5	AZ
Sculpins, family Cottidae				
Malheur mottled sculpin	*Cottus bairdi ssp.*	SC	1	OR

*1—Present or threatened destruction of habitat
2—Overutilization
3—Disease
4—Hybridization, competition, exotic or translocated
5—Restricted natural range

A. I consider 200 pupfish to be one which puts the species in approximately the position it was prior to the appearance of man—not completely in that position, but approximately. Now it's as threatened as it always was because of its restricted habitat, but it is no more threatened because of man's activities.

Q. Would cleaning up the waters here in the West affect the species population?

A. In those areas where pollution is a problem it certainly would. Almost anything that's proposed which will modify habitats must be examined with respect to the possibilities of adversely affecting species, whether or not they are endangered. It doesn't necessarily mean that, for instance, salinity control projects will affect the woundfin minnow. In fact, some of my work has demonstrated that there is probably a good opportunity to design salinity control projects that will be unlikely to affect the mainstream fishes of the Virgin River. That conclusion is expandable to many other instances in the Southwest. The important thing is to design projects that are compatible with the habitat requirements of the species impacted. In other words, cleaning up the waters of the West could affect species in a number of ways, both adversely and favorably.

Q. I'm not convinced that what you have said about the proposal to not go ahead with the power plant in Dixie is reasonable. The suggestion was that they divert some of the water from the Virgin River into a reservoir in Warner Valley and with that carry on with their electrical work. Now, of course, it would be a coal plant and this would be cooling water for the hydro plant. What is the problem? How is it going to endanger that fish?

A. The question is how is the Warner Valley Project likely to add to the threats to the woundfin minnow and roundtail chub in the mainstream Virgin River. Thanks very much for asking it, Vasco (Tanner). This obviously is not a simple problem. The basic answer I see is that the Warner Valley Project as projected will alter the flows of the mainstream Virgin River. The hydrologists point out that most of the water will be taken during the winter and spring. Data I presented here today indicate that during the low-flow winter, spring, and summer of 1977, woundfin and roundtail chub reproduction was extremely low. To the extent that the Warner Valley Project increases the frequency with which flows similar to 1977 occur, that project will adversely impact the endangered fishes living there. Essentially, the problem is that the data so far demonstrate that 1977, which was a low-flow year, resulted in conditions incompatible with very much reproduction of those two species. If you cut off that reproduction, you're likely to cause an extinction. Certainly every time you modify the flow regime of the Virgin River such that the native fish populations living there miss a year of reproduction, you're very demonstratively affecting the capability of those species to maintain themselves in the river. My conclusions here are really based on the fact that we have demonstrated very poor reproduction during a time which represents the kind of postproject flows we could expect.

Q. Of course I've seen that river fluctuate from great to almost nothing, so naturally I don't see that there is any justification for not going ahead with it. They're going to get water from Warner Valley as well as just divert a little from the Virgin River into the reservoir.

A. The crux of the matter, I think, is what flows are necessary to permit reproduction of the woundfin minnow. The data I presented suggest that flows in the neighborhood of 100 cubic feet per second are necessary to permit reproduction of woundfin and roundtail chub. In fact, there is some suggestion that winter flows must be somewhat higher. If the Warner Valley project doesn't reduce winter and spring flows below about 110 cubic feet per second, then I would say that there is likely to be no adverse impact. On the other hand, if it does, and it was demonstrated by the hydrological study that it would, then it does represent an impact. I'm not saying you shouldn't have the project. All I am saying is, if you reduce flows, you're going to impact the minnow and the chub.

Q. Just a comment more than a question. I understand the Warner Project during 1977 would not have been allowed to divert because the water was so low that project requirements would not have permited diversion. The 1977 situation would not be repeated unless there was another low-water year.

A. If that's the case, then I fail to see the basis for the rather marked objections that have been raised to the conclusions I have reached.

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RARE AQUATIC INSECTS, OR HOW VALUABLE ARE BUGS?

Richard W. Baumann[1]

Abstract.— Insects are an important element in the analysis of aquatic ecosystems, (1) because the limited dispersal abilities of many aquatic species means that they must make a living under existing conditions, and (2) because they are often sensitive to slight changes in water and stream quality, thus making excellent indicators of the physical and chemical conditions in a system. Examples of rare, ecologically sensitive species are presented from the Plecoptera, Ephemeroptera, and Trichoptera. Detailed studies of rare aquatic insect species should produce important information on critical habitats that will be useful in the protection of endangered and threatened species in other groups of animals and plants.

I use the term *rare* instead of *endangered* or *threatened*, because no aquatic insects are presently on the United States list of endangered fauna. The term is still relative, though, because my experience indicates that nearly every species can be plentiful if sought at the right place at the right time.

Aquatic insects are useful to anyone studying aquatic habitats because they usually meet two criteria that are essential in assessing aquatic systems. First, they often have very limited dispersal abilities, which means that they must stay and make a living under existing conditions. Second, they are often sensitive to slight changes in water quality, so their presence or absence tells something about the physical and chemical conditions in the system.

Because the conditions present in a given habitat determine which species can live there, these organisms become living indicators of water quality in aquatic ecosystems. If these organisms are invertebrates which exist at low levels in the food web, this is an advantage. Invertebrates are easier to study than are larger animals, because they are more abundant and usually do not carry the emotional stigma associated with large vertebrates. They can also indicate adverse habitat problems sooner, so that adjustments can be made in water or stream quality before the top carnivores are severely affected.

During my studies of aquatic insects in western North America, I have found that the distribution patterns of certain species fit nicely with a model of island biogeography. Many stoneflies (Plecoptera) are mostly restricted to pristine habitats characterized by cold, clean continuously flowing streams at high elevations or in special spring-fed habitats. It thus follows that if the particular habitat in which they occur is threatened, then they almost automatically become rare and may become extinct. Such species populations are often considered relicts of faunas that were once more prevalent when more ideal conditions occurred.

Studies on the stonefly genus *Amphinemura* (Baumann and Gaufin 1972, Bauman 1976) showed that it was a Palearctic genus that had extended into the Neotropical Realm and was still present in western North America in limited relictual populations. Although four species showed fairly wide distribution patterns in the United States and Mexico, three species were restricted to a single mountain range. *Amphinemura apache* occurred in the Chiricahua Mountains of Arizona, *A. reinerti*, was limited to Sierra Potosí, Mexico, and *A. puebla* was found in a mountain drainage near Veracruz, Mexico.

These *Amphinemura* species are poor fliers and almost need a water connection for dispersal. They live only in small streams that flow all year around and are of high quality. Their distribution patterns closely follow the spruce-fir and high pine forests in the southwestern United States and Mexico. They are

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thus good indicators of a special aquatic habitat in western North America.

Another example of restricted distribution in the stoneflies is *Capnia lacustra* Jewett, which only occurs in Lake Tahoe. It carries on its entire life cycle under water at depths of 100–400 feet (Jewett 1963, 1965). Only one other similar stonefly is known, and that is the genus *Baikaloperla* (Zapekina-Dulkeit and Zhiltzova 1973), in Lake Baikal, Siberia. It is also wingless and possesses similar morphological and ecological traits. It is not surprising that these two deep, ancient lakes contain similar rare species which evolved under specialized conditions and will be lost if their habitat is destroyed.

Much attention has been given to several fish species that occur in the Colorado River drainage such as the Humpback Chub, Razorback Sucker, and Colorado River Squawfish. These fish developed through time in another type of specialized habitat that excluded the salmonids and allowed other taxa to radiate into the open niches. Invertebrate species have also developed under similar conditions and several forms also occur in the Colorado River drainage. Edmunds (1976) lists several mayfly species which are rare and restricted to the Colorado River drainage and similar large warm rivers in western North America.

The following are a few examples of rare mayfly species and an indication of where they occur in the United States: *Analetris eximia*, Green River; *Lachlania saskatchewanensis*, Green, Colorado, and White Rivers; *Anepeorus rusticus*, Green River; *Homeoneuria* sp. Escalante and Colorado Rivers. These invertebrate species provide additional evidence that our large, warm, western rivers contain animal species that have adapted to special conditions critical for their survival.

Caddisflies or the Trichoptera are interesting insects that occur in a wide variety of aquatic habitats. Most are good fliers and distribute freely, but many species are restricted to a certain habitat because of the larval requirements.

Wiggins (1977) published an outstanding work that makes it possible for any trained biologist to classify caddisfly larvae to genus. Thus it provides another tool for evaluating habitats using aquatic insects. A few interesting examples and their special habitat requirements are: *Goriella baumanni*, organic ooze in spring seeps; *Psychronia costalis*, small meadow streams above 8,000 feet; *Desmona bethula*, small spring streams.

The number of rare aquatic insects is quite large because of the number of different aquatic habitats available and the ability of insects to fit into relatively small niches within those habitats. This is actually a positive value, however, because it allows the researcher to more closely understand the ecosystem since it can be divided into smaller parts.

Two final examples of rare insects that have very specific habitat requirements are the met-winged midges and the water penny beetles.

Net-winged midges are flies which have become adapted to living in torrenticolus habitats. The larvae are greatly modified into chitonlike organisms that attach themselves to the substrate by sucking discs. They live only in clean, cold, well-aerated waters which have a stable, smooth-grained substrate. Thus they can be excellent indicators of these habitat conditions that occur at falls and quick-flowing mountain torrents. Hogue (1973) lists several Blephariceridae species that are presently known only from a single locality or mountain range. This is not simply an artifact of incomplete collecting, but a result of poor adult dispersal ability plus the very specialized habitat requirements of the larvae noted earlier.

Water penny beetles have an adult stage that looks like a terrestrial beetle but a larval stage that is highly modifed for life on the bottom of streams. The larva is greatly flattened so that the head and appendages are completely hidden under the thoracic and abdominal sclerites. The single eastern species *Psephenus herricki* is rather widely distributed, but the five known western species have very restricted distributions (Brown and Murvosh 1974). Two species, *P. montanus* (White Mountains, Arizona) and *P. arizonensis* (Chiricahua Mountains, Arizona) have very limited areas of occurrence. An interesting note is that this type of limited distribution pattern is also exhibited by several species in the Plecoptera, Trichoptera, and Ephemeroptera.

Many more examples of "rare" aquatic insects could be given which probably fit into the endangered or threatened categories as presently understood. They are exciting to me for pure scientific studies of zoogeography and phylogeny. However, I feel that the real value is not simply to say "I found another rare creature," but instead to make us more sensitive about the critical habitat conditions which produced these rare species.

Insects tend to be more abundant and are thus easier to study without affecting population dynamics. They are also usually more economical and easier to sample because they are less mobile and can be effectively studied by fewer people with less sophisticated equipment.

On the other hand, politicians and business people may question the value of an insect. Who cares about bugs? How much is a bug really worth?

This problem can be illustrated by an incident with which I was involved while at the Smithsonian Institution. Soon after my arrival in Washington, D.C., I was asked to look through the aquatic insects for which I was responsible as curator and add any species to a list of organisms that could be considered both rare and restricted to the Chesapeake Bay area. In Ross and Ricker (1971) I found a stonefly species, *Allocapnia zekia*, that was known only from the Zekiah Swamp, La Plata, Charles County, Maryland. I added it to the list and forgot about it. About three years later, I received a telephone call from a man who wanted to know all about the "Zekiah Stonefly." At first I did not know what he was talking about, but when he mentioned the Chesapeake Bay species list, I remembered. I did some quick research and indicated that the species was based on a single, male holotype and might possibly be a synonym of a widespread eastern species. He nearly exploded when I reported this to him, because, he said, that "Zekiah Stonefly" was holding up the construction of a water plant in a nearby community and was costing a lot of people a lot of time and money.

In summary, it is important to understand our special environmental problems here in North America. If this can be better facilitated by using aquatic insects, then we should place renewed emphasis on studies of them. We must, however, be aware of the fact that people in general do not understand the scientific value of insects and might react poorly to "bugs" being used to justify the preservation and conservation of special ecosystems. However, scientific investigations of high quality must utilize all possible avenues of investigation if problems are to be solved with a minimum expenditure of time, effort, and resources.

It is also important that we do not attempt to overstate the value of "rare" species as habitat indicators. Some states, for example, have placed entire orders such as the Plecoptera (stoneflies) and Ephemeroptera (mayflies) on lists or proclamations and have diluted their value. When this is done it becomes difficult to study these organisms, because of the problem involved in obtaining permits and permission to collect specimens. Collecting alone will probably never seriously harm an aquatic insect population, as has occurred with many butterfly species, but habitat manipulation will.

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ENDANGERED AND THREATENED PLANTS OF UTAH: A CASE STUDY

Stanley L. Welsh[1]

ABSTRACT.— Endangered and threatened plants of Utah are evaluated as to their distribution in phytogeographic subdivisions, substrates, plant communities, elevations, and geological strata. The phytogeographic subunits were partitioned and comparisons made of distribution as outlined for the parameters cited above. A predictive model is suggested based on the nonrandom distribution of endemic plant species.

The Endangered Species Act of 1973, Public Law 93-205 (as ammended 1978), was an outgrowth of decades of concern regarding the future of that portion of our heritage of living things, which, by the nature of their distributional patterns, could most easily be eradicated as man pressed to exploit the resources of the earth, both finite and renewable. The act dictated an orderly process for development of lists of endangered and threatened species, defined terminology, and provided for development of criteria for determining candidate species.

Plants are the mantle of the land, nourishers of life's feast, holders of soil, suppliers of construction materials, of medicines, and of other substances too numerable to mention. They provide the basis of all life on earth, save some few living things which are capable of chemosynthetic utilization of energy. This fact and the list of materials that flows from plants need not be mentioned. Yet, the spread of mankind over the face of the earth, his development of agriculture, and, more especially perhaps, his development and spread of an industrial society with its great demands on space and materials has resulted in a direct competition for the space that was, or is, occupied by the indigenous flora of the earth.

The clearing of agricultural land for planting of crop plants, as selected from that indigenous genetic stock available as portions of the total flora, was possibly the beginning of the role of mankind as a major agent for reduction of plant species. Even those from which the crop plants were developed were not spared from destruction or modification.

Agriculture is, nevertheless, a more efficient means for the production of biological materials that can be consumed by man and by his livestock than from the previously employed methods of gathering and hunting.

Industrialization merely speeded the process by which agricultural lands could be cleared of native plants and those lands then maintained in single crop cultures. With industrialization came the explosion of demands for resources of many kinds: ferrous and nonferrous metals, chemical compounds of all kinds, sand and gravel, coal and oil, uranium, and other naturally occurring materials.

The mantle of the land gave way as each new source was discovered. Roads were cut through the vegetation. Quarries, open pit mines, portals, corridors, industrial plant sites, pipelines, villages, towns, cities, garbage dumps, litter, and other features of civilization were placed atop the shrinking vegetation.

Into the vast array of plant species marched also an infinitesimally small cadre of

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persons determined to know about the plants themselves—to name them, to describe them, to plot where they grew, and to recognize that there is an intrinsic value in each plant species, no matter how insignificant it might be considered. Botanists they were called, whether by training or by inclination they arrived at a point where plants become their pursuit. At first, all botanists were taxonomists. Later, not even all taxonomists were taxonomists.

Late in the human story the taxonomists began to catalogue the vegetation of the earth. Systematic surveys of vegetation and collections of plant species began in earnest only in the eighteenth century, in North America not until the nineteenth century, and in Utah the main thrust did not come until the twentieth century.

By the beginning of the third decade of the present century, the common plant species and their general areas of growth were well known. The work of the various government surveys and of pioneer botanists had penetrated even to some of the most remote regions of western North America. Discovered were some of the most rare of species, but others remained undiscovered.

Cognizant of the increasing demands of a growing population and an expanding civilization, botanists, always too few for the task, were hard pressed to survey all of the remote regions in a systematic manner. Collections were taken in a haphazard way. A trip to the hot desert in springtime, another to the cool mountains in midsummer, and by autumn the enthusiasm for collecting was cut short, too often by the need for gainful employment—because botanists could seldom be gainfully employed as botanists.

As the search areas narrowed, and as collections were taken in a more systematic manner, the number of known narrowly restricted plants increased proportionally. A still finer search may yet yield many additional narrowly adapted endemics. They are plants of all elevational ranges, but they are most common in highly specialized habitats, those which are likely to be occupied by other narrowly restricted plants also.

Often the species belong to difficult or to purportedly difficult taxonomic groups, such as *Astragalus*, *Eriogonum*, *Erigeron*, and others. Few people have taken the time to understand these complex assemblages, or to even collect and attempt to identify them. Fortunately, monographers have examined many of the problem genera and have clarified the nature of taxonomic limits, often on the basis of very limited materials.

Passages of the Endangered Species Act found botanists in most regions of the United States ill prepared to provide definitive information regarding candidate plant taxa, which had been included in the act mainly as an afterthought. Despite the lack of specific information, the act called for the secretary of the Smithsonian Institution in Washington, D.C., to report to Congress within one year on all of the "species of plants which are now or may become endangered or threatened" in the United States (Section 12, Public Law 23-205). In December 1974, the secretary of the Smithsonian Institution, S. Dillon Ripley, submitted a "Report on Endangered and Threatened Plant Species of the United States" to Congress.

That report formed the basis of the 1 July 1975 Federal Register (Vol. 40, No. 124: 27824–27924), which contained a review of the endangered and threatened plant species. The number of species assigned to those categories for the twelve western states (exclusive of Hawaii) is presented in Table 1. That pre-

TABLE 1. Number of species reviewed as endangered and threatened in 1975 and proposed as endangered in 1976, in twelve western states.

	Date		
	1975 Status		1976 Status
STATE	E	T	E
Alaska	9	21	6
Arizona	65	106	66
California	236	412	286
Colorado	23	17	32
Idaho	21	41	21
Montana	2	8	3
Nevada	43	84	50
New Mexico	15	26	20
Oregon	43	135	51
Utah	56	101	66
Washington	16	72	18
Wyoming	3	18	8
Total	582	1041	627

Grant total = 1623

liminary list of 1975 was based on the best information available to scientists at the Smithsonian Institution working in collaboration with those from the Department of the Interior. The lists were reviewed by selected specialists and botanists at a workshop held at the Smithsonian in September 1974.

That the 1975 lists were preliminary is to be found in the differences in numbers of endangered species published in the Federal Register (Vol. 41, No. 117: 24524–24572) published on 16 June 1976 (Table. 1). Even in such states as California, with its formidable number of qualified professional taxonomists and amateurs, the number of endangered plant candidates increased significantly between 1975 and 1976. No such comparable list is available for candidate threatened plants, but some of the increase in endangered species is represented in change of status from threatened to endangered (Kartesz and Kartesz 1977).

Impetus for acquisition of knowledge of rare plant species was generated by the lists of 1975 and 1976, and by the policy of active search for information required by governmental agencies, which was built into the act. Funds were forthcoming from various federal agencies to make determinations of range, habitat, condition, impacts, and potential impacts, and for other information on the candidate species. Rule making was entered into by the U.S. Fish and Wildlife Service, Department of the Interior, and, at present, some 20 species of plants have been determined as endangered or threatened. Two of these, *Astragalus perianus* Barneby and *Phacelia argillacea* Atwood, are from Utah (see Federal Registers Vol. 40, No. 81: 17910–17916, and Vols. 43, No. 189: 44810–44812, respectively). The former is listed as threatened, and the latter is listed as endangered.

Impacts of the act have been widespread. It has been subjected to political and emotional, as well as to scientific, evaluations. The act has been modified to some extent as a result, but those evaluations are not the basis of this contribution. Rather, I intend to pursue the developmental basis of information dealing with endangered and threatened species, and to outline one basis of the nature of those critical plants.

BIOLOGY OF ENDANGERED AND THREATENED SPECIES

The biology of endangered and threatened species in Utah is, with few exceptions, the biology of narrowly restricted endemics. Therein lies the basis for disparity between lists and category representations. The amount and quality of botanical knowledge of common species is seldom sufficient to allow more than generalizations; that for rare species is likely to be lacking altogether. The task of surveying vast areas for narrowly restricting plants is a huge one, carried out in the past largely by individuals with much devotion and little financing.

Too, the fact that a plant is an endemic and is rare has often been considered as evidence of endangerment. Lists are replete with such examples, but studies have indicated that rare plants might not be endangered or threatened, and that plants thought to be rare were in fact relatively common and widely distributed. For a plant to be a candidate for inclusion on final lists of endangered and threatened plant species, it must have endangerment, both quality and quantity, clearly demonstrated.

Contemporary studies are under way to aid the Department of the Interior with decisions necessary for final rule making. Studies of distribution, population numbers, degrees of endangerment, and many other facets are being undertaken, which will lead to development of information summaries of all species which have been reviewed, proposed, or recommended.

Much information has already been gleaned from the specimens extant in herbaria. For the purpose of this paper, endangered and threatened plant species from Utah will be used to illustrate the contemporary knowledge of status of those species, and to provide the model for a case study of the nature of those species.

A list of endemic and rare plants of Utah was prepared by Welsh, Atwood, and Reveal (1975). In that publication, some 382 vascular plant taxa were considered, with 66 regarded as endangered, 198 as threatened, 7 extinct, and 20 extirpated. Only 225 species were considered to be endemic to Utah. The numbers are not comparable to those published in

the Federal Registers due to consideration of species with broad distribution, a portion of which includes Utah, within the threatened and endangered categories. In later computations the number of endemic species is cited as 239 (Table 2). Welsh (1978) published a reevaluation of the endangered and threatened plants of Utah, in which some 53 species are regarded as endangered and 99 as threatened. Numbers in this latter publication are not comparable to those of the Federal Register lists due to deletions and additions.

That the biology of endangered and threatened species is that of restricted local endemics is found in the nonrandom distribution of those species. Utah can be divided into eleven phytogeographic subunits, each topographically, geologically, and phytologically different (Table 2). The numbers of endangered and threatened plants is approximately proportional to the number of endemic species in each phytogeographic subunit. Endemics constitute 27 percent of the total for the Navajo Basin; endangered and threatened plant species of that basin make up 28 percent of the total for the state. Proportions are similar for Plateau, Tavaputs, Uinta Basin, and all Gther phytogeographical regions. Approximately 64 percent of all endemic species in these areas are considered as endangered or threatened. It is axiomatic that endemics should constitute the endangered and threatened candidates when the small areas occupied by them are considered.

Endangered and threatened species of the Navajo Basin and Plateau subunits constitute half of the total number for Utah. Other important regions include the Uinta Basin (13 percent), Great Basin (13 percent), and Mohave (14 percent). The remaining areas include only 11 percent of the species on candidate lists in total.

In general, endangered and threatened plant taxa in Utah occupy harsh substrates which are perceived by man as barren or nearly barren of vegetation. Hence, these critical species tend to occur in areas where there is little competition. Survival of the species depends on maintenance of the habitat in a condition wherein other species do not become competitive. Protection, as herein conceived, involves guarantees against man-caused destruction of habitat. Natural changes should not be treated as endangerment.

Phytogeographic Subunits and Endangered and Threatened Species

The distribution of critical species does not appear to be at random on the substrates available, and those substrates which support these species are not occupied uniformly. Rather, specific portions of apparently similar substrates are occupied, while others are not. Clays and other fine-textured colluvial or aeolian materials and limestones are the most commonly occupied substrates (Table 3). Together, they form the substrates of 81 percent

TABLE 2. Comparison of endemic, endangered, and threatened plant taxa by phytogeographic subdivision within Utah.

	Endemics		Endangered		Threatened		Total E & T	
Phytogeographic unit	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Colorado canyons	7	3			1	1	1	1
Navajo Basin	65	27	17	32	25	25	42	28
Plateau	48	20	11	21	22	22	33	22
Tavaputs	3	1	2	4			2	1
Uinta Basin	25	10	8	15	12	12	20	13
Uinta Mts.	4	2			4	4	4	3
Wyoming	3	1			2	2	2	1
Wasatch Mts.	23	10	1	2	6	6	7	5
Great Basin	35	15	7	13	13	13	20	13
Mohave	26	11	7	13	14	14	21	14
Pine Valley Mts.								
	239	100	53	100	99	99	152	101

TABLE 3. Endangered and threatened plant species arranged by substrate within Utah.

Substrate	Endangered Number	Endangered Percent	Threatened Number	Threatened Percent	Total Number	Total Percent
Clay, silt, mud	27	41	31	31	58	38
Sand	9	17	28	28	37	24
Gravel			2	2	2	1
Igneous gravel			9	9	9	6
Limestone	9	15	21	21	29	19
Talus	1	2	1	1	2	1
Loam-humus	4	9	4	4	8	5
Water			1	1	1	1
Unknown	4	8	2	2	7	5
	53	101	99	99	152	100

of the taxa on critical lists. Water-washed alluvial deposits tend to support a greater plant cover than do the in situ substrates or those deposited by wind. Hence, probably because of the greater amount of cover and competition, the vast areas covered by water-borne alluvial deposits mainly lack critical species. The exceptions include some gravel deposits, especially those derived from igneous extrusive or intrusive stocks.

Critical species are present in several of the major vegetative types within the state. As with other criteria, the taxa are not randomly distributed in all of the plant communities. Pinyon-juniper, desert shrub, warm desert shrub, and salt desert shrub vegetative types bear 65 percent of all endangered and threatened candidates (Table 4). These are communities which lie within a low precipitation regime, wherein edaphic features are not insulated from plants by well-developed soil horizons or by organic matter within the soils. Edaphic features are the main controlling factors within low-elevation plant communities.

Even where plants of a critical nature are present within a community which tends to occupy most of the surface area, and where soils are well developed, thus preventing direct edaphic control, the endemic species are found mainly in clearings, along bluff margins, on ridge tops, and on other poorly vegetated micro-habitats.

Adiabatic and lapse rate differentials are reflected in elevational differences. High elevation areas are cooler and receive propor-

TABLE 4. Endangered and threatened plant species arranged by plant community (the plant communities in approximate order by elevation).

Community	Endangered Number	Endangered Percent	Threatened Number	Threatened Percent	Total Number	Total Percent
Alpine			5	5	5	3
Spruce-fir	3	6	14	14	17	11
Aspen	2	4	1	1	3	2
Mountain brush	1	2	1	1	2	1
Ponderosa pine	2	4	7	7	9	6
Pinyon-juniper	17	32	27	27	44	29
Sagebrush	2	4	3	3	5	3
Desert shrub	12	23	4	4	16	11
Warm desert shrub	5	9	9	9	14	9
Salt desert shrub	4	8	22	22	26	17
Hanging garden			1	1	1	1
Aquatic			1	1	1	1
Other	1	1			1	1
Unknown	4	8	4	4	8	5
	53	101	99	99	152	100

tionally greater amounts of precipitation, resulting in production of mesophytic plant communities in those sites. Plant species of a critical nature are mainly xerophytes, regardless of the community type within which they occur. The large portion of species, some 60 percent of those designated as endangered or threatened, exist below the 6000 foot (1930 m) contour (Table 5). Possibly the reason for the great number of species at the lower elevations is due to the proportionally greater number of sites in arid lands which are open to colonization.

Chemical and water relations of substrates are closely allied to geological strata. Edaphic control by geological formations is greatest in areas where the strata are exposed. Layers of alluvium, which represent mixtures of materials from different sources, tend to insulate vegetation which grows on that alluvium from the chemical and water relations peculiarities of the individual stratum per se. Soil development reinforces separation of parent materials from plants. Hence, geological control of vegetative cover is greatest at lower elevations, where strata of many kinds are exposed over vast reaches. Soils as such are poorly developed or nonexistant due to low rainfall and the corollary lack of leaching of soluble salts.

There are regions at moderate to high elevations where edaphic factors of geological strata are controlling due to peculiarities of topography and geomorphology. Cliff faces and breaks at the margins of plateaus and ridge crests are examples of such places. In others, substrates which are very acidic or basic, as in some igneous or limestone strata, tend not to be insulated due to lack of growth of dense vegetation. Plant species of a critical nature occur on a series of geological strata ranging in age from Quaternary to Precambrian (Table 6).

There does not appear to be any particular stratum which bears a disproportionately large number of endangered or threatened species. The largest number is found on Quaternary alluvia, mainly on dunes or stabilized dune sand and on residual accumulations on the formations from which they were produced. Even this small number represents only 17 percent of the included species. Dunes are open habitats. They are mesophytic sites in otherwise arid lands. They represent an anomaly wherein competition is low, but where water is relatively abundant and available.

If mudstone, siltstone, and shale strata are considered collectively, some 37 percent of the species reside on them. Limestone or other highly calciferous formations, such as Flagstaff, Wasatch, and the Carboniferous strata, provide substrates for 17 percent of the total plant species. Sandstone and conglomeritic formations account for only 10 percent of the taxa.

Partitioning of the phytogeographic subdivisions demonstrates differences and similarities in areas of distribution, and in the control of that distribution. Disparity in geological strata is obvious from one subunit to the next, and potential substrates differ because of the different kinds of strata available. The Paleozoic strata of the Great Basin and of the Wasatch Mountains present an entirely different array than do the Uinta Mountains, Uinta Basin, Navajo Basin, and Mohave subunits. Plant communities reflect those substrate differences, often in subtle ways. Additionally, the phytogeographic subunits are topographic features whose definitions are tied to elevation.

Despite the problems associated with comparison, and the obvious differences—which should not require discussion—an analysis of the various phytogeographic subunits will be

Table 5. Endangered and threatened plant species arranged by elevation stratification.

Elevation	Endangered		Threatened		Total	
	Number	Percent	Number	Percent	Number	Percent
<6000 feet (1830 m)	34	64	58	58	92	61
6000–9000 feet (1830–2745 m)	13	24	30	30	43	28
>9000 feet (2745 m)	3	6	10	10	13	9
Unknown	3	6	1	1	4	3
	53	100	99	99	152	100

instructive in attempts at management of lands in the respective areas as regards endangered and threatened species. The total numbers of species in a given subunit might be indicative of trends (Tables 7, 8, 9, and 10).

Summaries of species number and percentages for substrates in each of the phytographic subunits demonstrates similarities between the Navajo Basin, Uinta Basin, and Mohave subunits (Table 7). In each of these, clay, mud, silt, and sand constitute the substrates of more than 85 percent of all critical plant species. Plateau subunit differs in bearing more than 50 percent of the included species on limestone, and with igneous gravels being second with 18 percent. Patterns in the Great Basin are obscure, with no single substrate supporting more than 25 percent of the species. Six of the seven species from the Wasatch Mountains are known from limestone. The other phytogeographic subunits bear so few species as to not demonstrate trends.

When plant communities are compared for each of the phytogeographic subunits, it is clear that pinyon-juniper and the various kinds of desert shrub communities support most of the endangered and threatened plant species in the Navajo Basin, Uinta Basin, and Mohave subunits in Utah (Table 8). Spruce-fir, ponderosa pine, and pinyon-juniper communities are the sites of occurrence of some 71 percent of the critical species in the Plateau subunit. Alpine and spruce-fir are the main communities of those species in the Uinta and Wasatch mountains.

The Navajo, Uinta, Great Basin, and the Mohave subunits bear 80 to 100 percent of the species below 6000 feet in elevation. In Plateau, Tavaputs, Uinta Mountains, and Wasatch Mountains all species are above the

TABLE 6. Geological strata as substrates of endangered and threatened Utah plant species (Note: species were assigned to only one stratum, the major one, even if they occurred on more than one. Strata without numbers of species, indicated by a dash, are known to support critical species; those not marked are not known to support them.)

	Threatened		Endangered		Total	
Strata	Number	Percent	Number	Percent	Number	Percent
Quaternary	18	18	8	15	26	17
Flagstaff			2	4	2	1
Green River	3	3	10	19	13	8
Bald Knoll	—	—	—	—		
Wasatch	9	9	4	8	13	8
Duchesne River	5	5			5	3
Tertiary Igneous	9	9	1	2	10	7
Kaiparowits	2	2			2	1
Wahweap	—	—				
Straight Cliffs	1	1			1	1
Mancos Shale	5	5	4	8	9	6
Tropic Shale	1	1	2	4	3	2
Mowry	1	1			1	1
Arapien	4	4			4	3
Cedar Mt.	1	1			1	1
Morrison	—	—	1	2	1	1
Entrada	2	2	1	2	3	2
Carmel	1	1	3	6	4	3
Navajo	5	5	3	6	8	5
Wingate	—	—				
Chinle	1	1			1	1
Moenkopi	7	7	5	9	12	8
Cutler	1	1	1	2	2	1
Cedar Mesa	1	1	1	2	2	1
Paradox	—	—				
Carboniferous	12	12	1	2	13	8
Precambrian	3	3			3	2
Unknown	7	7	4	8	12	8
	99	99	53	99	152	99

TABLE 7. Substrates of endangered and threatened plant species by phytogeographic subdivision in Utah.

Substrate	Colorado Canyons		Navajo Basin		Plateau		Uinta Basin	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Clay, silt, mud			23	55	2	6	16	80
Sand	1	100	16	38	4	12	3	15
Gravel							1	5
Igneous gravel			11	2	6	18		
Limestone					17	52		
Talus			1	2				
Loam-humus			1	2	2	4		
Water					1	3		
Unknown					1	3		
TOTAL	1	100	42	99	33	98	20	100

6000-foot contour (Table 9). Part of the explanation for this correlation is based on the definition of the subunits. The basins are mainly below 6000 feet in elevation, and the mountains are mainly above that figure.

Similarities of geological formations in chemical and physical structure seem to be more important than the geological strata by themselves. Cutler, Moenkopi, Chinle, Carmel, phases of the Entrada, Morrison, Arapien, Tropic Shale, Mancos Shale, and Duchesne River formations tend to resemble each other texturally, and in having high amounts of soluble salts. Each of these support one or more of the endangered or threatened species, some of which might be expected on others of those formations also. Indeed, some do occur on more than one formation, even though Table 10 is presented with only the major formation that serves as substrate represented. Differences and similarities between the subunits of the state are obvious. Geological strata in subunits of the Colorado drainage system tend to be most similar, but even in those there is a tendency for plants to react differentially, despite the similarities of stratigraphy.

PREDICTIVE CAPABILITY

Because of the nonrandom distribution of narrowly restricted species in Utah, it is possible to prepare a model with predictive capability which will aid in the search for these critical plants. The model, a sample of which is presented in Table 11, is based on deduc-

TABLE 8. Plant communities of endangered and threatened plant species by phytogeographic subdivision in Utah.

Plant Comm.	Colorado Canyons		Navajo Basin		Plateau		Tavaputs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Alpine			1	2	2	6		
Spruce-fir					9	27		
Aspen					1	3		
Mountain Brush							2	100
Ponderosa pine			2	5	8	24		
Pinyon-juniper			18	44	6	18		
Sagebrush			1	2	4	12		
Desert shrub								
Warm desert shrub			6	15				
Salt desert shrub			12	29				
Hanging garden	1	100						
Aquatic					1	3		
Other					1	3		
Unknown			1	2	1	3		
	1	100	41	99	33	99	2	100

TABLE 7 continued.

Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave		Tavaputs	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
						5	25	9	43	2	100
		2	100			4	20	9	43		
						2	10				
						1	5				
				6	86	5	25	2	10		
1	25										
3	75					1	5				
				1	14	2	10	1	5		
4	100	2	100	7	100	20	100	21	101	2	100

tions derived from the nature of the distribution of those species evaluated above. The reasoning behind the model is based on the unequal occurrence of the species with regard to several parameters. The probability of occurrence is determined by use of a numerically weighted system in which the parameters are given a value of zero, one, or two as indicated by the known presence of the species on specific portions of the state. For example, most of the species of restricted plants occur on the finely textured soils, the next highest proportion on dunes, in situ sand, and limestone, and the lowest on soils consisting of gravel, talus, loam, and humus. Hence, these substrate types are rated as two, one, and zero, respectively.

The example outlined in Table 11 is suggested for the state, but more finely partitioned models are suggested for each of the phytogeographic subunits. It would not be logical to apply a high numerical weighting to elevations below 6000 feet for areas within the Plateau phytogeographic subunit where practically all the known critically restricted plants are above that elevation.

Despite the usefulness of the suggested model, and its modifications, it is suggested that the model should be used as a planning tool only. There is no substitute for on-ground inspection and the collection of the general flora to provide information on actual presence of plant species. Wherever possible such on-site investigations should provide herbarium materials for deposit in herbaria, taken in such manner as not to con-

TABLE 8 continued.

Uinta Basin		Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
		3	60			1	14				
		1	20			5	71				
		1	20			1	14	1	5		
										1	5
8	40			1	50			3	15	7	33
9	45							10	50		
										2	10
3	15							4	20	9	43
				1	50			2	10	2	10
20	100	7	100	2	100	7	99	20	100	21	101

TABLE 9. Elevation of endangered and threatened plant species by phytogeographic subdivision in Utah.

Elevation	Colorado Canyons		Navajo Basin		Plateau		Tavaputs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
< 6000 ft.	1	100	33	80				
6000–9000 ft			7	17	24	73	2	100
> 9000 ft.			1	2	8	24		
Unknown					1	3		
	1	100	41	99	33	100	2	100

stitute a threat in and of itself. This will guarantee that information gained in field surveys will not be lost in the files of agencies and industries attempting to work on the lands of the state.

PERSPECTIVE ON THE ENDANGERED SPECIES ACT

Value judgements as to the role of plants of limited distribution have not stopped, slowed down, or even modified the course of human expansion through all of history until now. The present society has asked whether plant species should be eradicated as a part of the common good of our civilization. Value is a time-oriented function; that considered as valueless today might be judged as very valuable in the future. Numerous examples of minerals are known which support this observation. Plants have been surveyed many

TABLE 10. Geologic strata serving as substrates of threatened plant species by phytogeographic subdivision in

Strata	Colorado Canyons		Navajo Basin		Plateau		Tavaputs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Quaternary			4	10	3	9		
Flagstaff					2	6		
Green River							2	100
Bald Knoll								
Duchesne R.								
Wasatch					14	42		
Tertiary			2	5	7	21		
Kaiparowits					2	6		
Wahweap								
Straight Cliffs			1	2				
Mancos			8	20				
Tropic			3	67				
Dakota			1	2				
Mowry								
Arapien								
Cedar Mt.			1	2				
Morrison			1	2				
Entrada			3	7				
Carmel			3	7	1	3		
Navajo	1	100	4	10	2	6		
Wingate								
Chinle								
Moenkopi			3	7				
Cutler			2	5				
Cedar Mesa			2	5				
Paradox								
Carboniferous								
Precambrian								
Unknown			3	7	2	6		
	1	100	41	98	33	99	2	100

TABLE 9 continued.

Uinta Basin		Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
20	100			1	50			17	85	19	90
		2	40			5	71	1	5	2	10
		3	60			2	29				
				1	50			2	10		
20	100	5	100	2	100	7	100	20	100	21	100

times for sources of biologically active materials, e.g., alkaloids, vitamins, hormones, wonder drugs, and cortical steroids. Now they are again being surveyed for antitumor agents. Common plants are being surveyed first, primarily because of their ready availability. The rare plants will be reviewed as material becomes available. It would be a tragic irony if the best anticarcinogenic agent should be discovered in the leaves of a herbarium specimen of a species which had just become extinct.

Extinction occurs as a function of natural forces, or as a function of man-caused factors. The former is selective in reducing populations of living things. The latter is nonselective.

The reasons for extinction of narrowly restricted plants on the same outcrop might involve loss of a pollinator for one species, in-

TABLE 10 continued.

Utah (Note: Only the major formation is indicated where plants occupy more than one.)

Uinta Basin		Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
3	15					1	14	7	35	7	33
10	50										
4	20										
								1	5		
1	5										
								4	20		
1	5										
1	5										
										2	10
										2	10
										7	33
						5	71	5	25	2	10
		4	80								
		1	20	2	100	1	14	3	15	1	5
20	100	5	100	2	100	7	99	20	100	21	101

festation by insects or disease for another. A construction project might cause wholesale extirpation by removal of the entire community. The rate of man-caused extinction far exceeds the natural rate. Thus, extinction caused by man is not a part of the natural scheme.

The Endangered Species Act of 1973 made it possible for future generations to be involved in the value-oriented decisions. The act provides an advocate for generations yet unborn.

Genetic pathways are, despite all of the possibilities, essentially one-way streets. The route by which a species is formed is as important as the end result. The reconstitution of the pathway requires the same criteria as were present in the past, a functional impossibility to recreate. Thus, the loss of any species terminates a line which cannot be reformed. And, once gone, the question of value to mankind is deprived of practical significance.

The reason most of the proposed endangered and threatened plants are considered thusly is because the known populations are small and exist in very limited areas. Average distributional densities of one endangered species to each two or three thousand square kilometers, and of threatened species to values of roughly half that figure, give an approximation of their true paucity. Further, only a very small part of the total land surface is involved.

Distribution of rare species is not equal, as has been discussed above. Certain areas appear to lack them altogether, while other areas support concentrations of several species. Unless a specific mineral to be exploited is located within one outcrop which supports one or more species, or unless the area to be occupied by a particular development is large, there is no reason why modern expansion should impress any of the currently known endangered or threatened species. Even in these two exceptional instances there is no real reason to displace indigenous endangered and threatened species; the best site for industrial development is not always the only good alternative.

Thus, if developers, and if the governmental agencies which control development on federal lands, follow the requirements as set forth in the act, there is little question that many, if not all, of the plant species which are ultimately determined as endangered or threatened can persist in perpetuity. The question of value of these plants is not an issue; the areas occupied by these plants can be avoided.

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TABLE 11. Outline of a predictive model for establishing priority areas for study of endangered and threatened plants of Utah.

Numerical weighting	Substrate	Community	Elevation	Geology	Phyto Subunit
0	Gravel, talus, loam, humus	Other	9000	Other	Colorado Canyons, Wyoming, Pine Valley
1	Dunes, in situ sand, limestone	Spruce-fir Ponderosa	6000–9000	Sandstone, in situ sand and limestone	Wasatch Mts., Uinta Mts., Tavaputs Pl., Plateau
2	Clay, silt, mud	Pj-Des Sh variations	6000	Shale mud and siltstone	Navajo, Uinta, Mohave, Great Basin

MANAGEMENT PROGRAMS FOR PLANTS ON FEDERAL LANDS

Duane Atwood[1]

Abstract.— The plant phase of the Endangered Species Program is discussed from the point of view of a professional botanist in government service. Some of the new amendments are also discussed from a botanical standpoint. Federal agency programs and policies in the western United States are briefly reviewed. The strength of the Endangered Species Program is dependent upon input from qualified professional biologists in and out of government service. Some of the problems encountered in the program are outlined.

The comments I would like to make today are based on my experience with government agencies over the past several years. I do not speak as a representative of any government agency, although I have had experience with the Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and the Forest Service (FS). First of all, let me point out that professional people who work for government agencies have a very frustrating and difficult task. They want to get on with the job that should and could be done, but cannot because of regulations, policies, and conflicts with the management and planning staff. There is a communication gap between professionals and managers and planners that needs to be bridged somehow. Until recently, some of these agencies were strictly management and planning oriented. Passage of new federal laws and regulations, such as the Endangered Species Act (ESA), created a need for these agencies to hire professionals with specialized training. It must be recognized that managers and planners have a difficult job making the proper decisions for the best uses of our natural resources and still be in tune with the multiple use concept. Our job as professionals is to supply managers and planners with sufficient data on any given problem or project, as it relates to our area of responsibility and expertise, so they can evaluate the pros and cons and in turn make the proper decisions. The active support of the Endangered Species Program (ESP) varies from agency to agency and from state to state within a given agency. For example, California has an excellent and effective Threatened and Endangered (T/E) plant program at both the state and federal level. Both state and federal agencies there have active, qualified botanists. Additional professionals outside of government have also taken an active interest in the ESP.

In discussing various topics with the participants of this symposium, I was impressed with the need to clarify the responsibilities of the different agencies that participate in the ESP. As most of you know, the Fish and Wildlife Service has taken the lead in this program for terrestrial species and has the responsibility for developing and implementing regulations to guide other federal agencies and the states in meeting the purpose and intent of the ESP. To accomplish this task they have published guidelines to implement the Convention on International Trade for Endangered Species of Fauna and Flora, prohibitions on certain uses of endangered and threatened plants, criteria for determining critical habitat, and the Inner Agency Cooperative Section 7 Regulations. In addition, the Fish and Wildlife Service has the responsibility for the consultation process, as required by the Section 7 Regulations, and the listing and delisting processes. To most of us here the listing process is the activity the Fish and Wildlife Service should be moving forward with most rapidly. However, they have a disproportionate share of the work load and budgeting restrictions have been placed on them. Other major responsibilities of the Fish and Wildlife Service include law

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enforcement, land acquisition, cooperative agreements with states, and development of recovery plans and/or teams. The new amendments to the ESA require some changes in the program. One of the new amendments now allows for the acquisition of land for plants. Prior to these new amendments, Section 5 of the act, regarding land acquisition, was only for wildlife species or plants officially listed and concluded in appendices to the convention. This new amendment is a breakthrough for plants. As I understand it, the Forest Service, as well as the Department of the Interior, can now acquire land for plants. Formerly, the Department of the Interior was the only federal department that could acquire land. Additionally, there is the new requirement for development of recovery plans for all officially listed endangered and threatened species. In Utah we have two plant species officially listed that are either on or adjacent to Forest Service Lands. We will be developing additional background data for use in these two recovery plans. I have two slides on them. The first is of *Astragalus perianus*, which is endemic to two locations in the central part of Utah at high elevations. The species was originally collected in 1905 by some of our early botanists, but was not rediscovered until 1976. The other species is *Phacelia argillacea*, which is endemic to the Green River Shale formation along the railroad right-of-way in Spanish Fork Canyon. This is the only existing population that we know of, and only nine individual plants exist, based on counts made in 1978. In view of the restricted nature of this species, the Fish and Wildlife Service will place this one high on their priority list for development of a recovery plan.

The various phases of the program that the Fish and Wildlife Service are trying to develop and implement directly affect the activities of other federal agencies, particularly land-managing agencies such as the BLM, Forest Service, and National Park Service. As most of you know, the Forest Service and BLM are trying to develop active programs. The National Park Service apparently takes the position that threatened and endangered species in the parks are already protected and that they don't really need to do anything. However, as Stan Welsh pointed out, the influx of people into these areas does have a detrimental effect on many T/E species that exist there. Some of the other agencies who have no lands to manage but have an impact on endangered and threatened species are the Bureau of Reclamation, the Soil Conservation Service, and the Navy, Army, and Air Force. For example, projects with which the Bureau of Reclamation is involved will destroy habitat. There is, therefore, a direct conflict with the purpose and intent of the ESA when endangered or threatened species are impacted by those projects. Some of those agencies are making no effort to determine the impact their projects have on these species. We as professionals, I feel, have the responsibility to become aware of their projects and to help provide these agencies with data and expertise. The trend among federal agencies is to solicit information and public opinion on various projects. How many of you are responding?

To comply with the objectives and policies of the Endangered Species Program, the BLM, Forest Service, and Fish and Wildlife Service have developed the following policy to insure protection for T/E species prior to official listing and protection under the Endangered Species Act. These agencies are considering all species that are likely to become endangered or threatened as though they are already officially listed to insure their actions do not jeopardize the existence of these species or modify their critical habitats. The degree of implementation varies within each agency from state to state and even within a given state. The strength of the program at these levels is dependent upon the professionals available to insure program development. There are very few plant taxonomists in government to help guide the program. Therefore, the scientific community must become more involved if we are to achieve a realistic program. The benefits of such a policy are fourfold: (1) protection of sensitive species prior to listing, which can and will meet the purpose and intent of the 1973 ESA, thereby (2) preventing the need for official listing of many T/E Species, (3) resulting in fewer legal restrictions and more management options for agencies, and (4) creating more benefits to the species and

project development. A major concern of federal agencies is to meet the requirements of Section 7 of the ESA, which reads

> The Secretary shall review all programs administered by him and utilize such programs in furtherance of the purpose of this act. All other federal departments and agencies shall in consultation with and with the assistance of the Secretary utilize their authorities in furtherance of the purposes of this act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to Section 4 of this act and by taking such action as necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existance of such endangered and threatened species or result in the destruction or modification of habitat of species which is determined by the Secretary after a consultation with the affected states to be critical.

However, the overriding concern is to meet the purpose and policy of the ESA, ". . . to provide a means whereby ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species . . . [and the] . . . policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."

It is my interpretation that the intent in the purpose and policy of the act is to conserve and protect species likely to be endangered or threatened with extinction in the foreseeable future. John Spinks has indicated that the Fish and Wildlife Service will only be able to list 20 to 30 species of plants in 1979. This is less than 1 percent of the 1785 proposed species. The Forest Service and Bureau of Land Management policy, if it is enforced, will provide the necessary protection for species which would otherwise become extinct due to the slow listing process. Furthermore, such a policy will minimize the need for official listing under the ESA.

Two other major problems in the plant program come to mind: (1) a lack of data on candidate and proposed species, and (2) inadequate lists of threatened and endangered plants. The latter is a result of insufficient data. Therefore, we must emphasize the need for additional inventories to determine the range of these species, their habitats, information on population biology, threats to their survival, and management problems. Presently a lack of funds is the biggest obstacle in developing an efficient data base. Some contracts have been let, and the current trend is to acquire these data through new contracts. Once we determine the locations of the T/E plants, we have to go back to these specific locations and obtain sufficient data for use in management programs. My assigned topic today was on management programs for plants on federal lands. The fact is federal agencies have formulated few or no management programs for most plants because we are in the inventory stage at the present time. We do have sufficient data on some species to make recommendations on listing or delisting from candidate and proposed lists and establish monitoring studies for others. The purpose of these monitoring studies is to acquire additional data on the status of the populations, their trends, condition of the habitat, and the biological needs of the species to develop realistic management programs for their protection and recovery, if possible.

California has an active program that places them well ahead of other states. Most of the other western states are developing programs. Much of this effort is from the professional and private sectors and the rest from federal and state agencies. The state government, in most states, has shown the least interest and, in general, leans more to development. Four federal agencies will issue contracts for plant inventories in Utah this year. It is hoped these studies will be conducted by qualified professionals. In addition, we have established coordinating committees for state, federal, professional, and amateur botanists in most of the western states to avoid duplication of effort and coordinate program activities. Botanists in Utah have now established a Utah Native Plant Society. One function of the society will be to help implement a T/E plant program for the state. It is hoped our program will be as successful as that in California. We solicit your membership if you have an interest in the native flora of Utah.

Most federal agencies do not employ plant taxonomists. Fortunately, they do have some biologists with sufficient interest and background to help develop a plant program. The

Forest Service will hold training sessions for existing range and wildlife staff to familiarize them with T/E species in their areas of responsibility. As a zone botanist, I am responsible for the Forest Service T/E plant program in Utah and Nevada. Within this area there will be from two to three hundred projects requiring site inspections for T/E plants. With the current level of funding and available staff we can expect to look at only 10 percent of these projects until more funding and personnel are available. We have, therefore, prioritized the species and areas to be worked on. The initial effort is on critically endangered species. The following slides illustrate some of these. The first is *Phacelia argillacea*, which, as I mentioned earlier, is officially listed. Next is *Townsendia aprica*. It is known only from two populations and, as Stan Welsh indicated, one population had been destroyed by a gypsum operation. Only one population remains. *Arctomecon humilis* is restricted to the Moencopi formation in Washington County, Utah. It is more common, but the impacts to the area are so severe that immediate listing is necessary to insure protection.

Government-funded inventory contracts have resulted in range extensions for many of the proposed species, as well as the discovery of new species. *Psoralea pariensis* is a species described in 1975. Just a few years ago, *Primula specuicola* was known only from a few collections along the Colorado River drainage system. Recent studies, as a result of the ESA, have provided many new locations and, even though from 30 to 40 percent of the habitat has been inundateed by Lake Powell, official listing is not necessary.

In the West, much of the land is administered by federal agencies. Table 1 illustrates the number of acres under Forest Service, Bureau of Land Management, National Park Service, and Fish and Wildlife control. Probably 5 percent or less of all these acres will constitute critical habitat requiring protection for T/E plant species. However, until our inventories are complete, we will not know where that 5 percent of the 632,992,185 acres is. Again we must use a priority system for inventories, based on the minimal data available. To show another relationship, I have outlined the number of candidate, possibly extinct, proposed and officially listed species by state. Currently there are 15 plant species officially listed. More than half of them occur in California.

The new amendments now include plants in Section 6 of the act under Cooperative Agreements. Table 2 outlines the status of cooperative agreements with states prior to the new amendments. Even though plants were not included in Section 6 of the act, originally four states submitted proposals to the FWS requesting funds for plants. Naturally, none have qualified. However, Utah submitted

TABLE 1. Number of acres and T/E plants in the western United States.

State	BLM admin. acres	USES admin. acres	NPS admin. acres	FWS admin. acres	(1975 FR) Number of Candidate threatened species	(1975 FR) Possibly extinct species	(1976 FR) Number of Proposed endangered species	Officially listed plants* Threatened	Officially listed plants* Endangered
Alaska	272,673,528	20,622,014	7,306,037	22,236,273	21		6		
Arizona	12,596,043	11,219,839	1,629,943	877,200	106	5	65		
California	15,577,909	20,327,515	4,258,2123	68,944	415	28	282		13
Colorado	8,354,671	13,773,966	535,050	51,947	18	3	32		
Idaho	11,985,079	20,342,387	86,425	40,944	41		21		
Montana	8,141,498	16,767,962	1,159,505	539,340	8	1	3		
Nevada	48,373,664	5,112,755	262,321	2,202,045	85	6	48		
New Mexico	12,956,665	9,106,299	241,621	316,183	26	3	19		
Oregon	15,739,792	15,486,367	160,881	466,011	135	2	51		
Utah	22,641,037	7,990,271	888,936	97,944	102	7	65	1	1
Washington	306,692	9,069,287	1,801,428	128,466	72	2	19		
Wyoming	17,536,891	8,679,047	2,310,653	44,787	18	3	8		
Totals	446,883,469	158,397,709	20,640,923	7,070,084	1,047	60	619	1	14

*22 species of the T/E plants have been officially listed.

their proposal in June 1977 for both plants and animals and is close to qualifying. This is based on my conversation with the Washington office of the FWS. Some states have heritage programs, and research natural area councils that have been extremely helpful in developing plant programs for the respective states.

Your attendance at this symposium is evidence of the interest shared by many Americans in preserving our unique flora and fauna. We can have the necessary development to sustain us and still preserve these valuable resources by having an open mind to the problems at hand. Let's help close the communication gap between scientists, environmentalists, and politicians.

QUESTIONS FOR DR. ATWOOD

Q. Is the listing of these taxa being coordinated because there are so few that are going to be listed? There are strategies whereby protecting one species in a very interesting habitat would preserve maybe four or five others in the same area.

A. It's my understanding that the Fish and Wildlife Service in-house policy is to develop listing packages on individual species. I think the best approach would be an ecosystem concept where there are two or three species, such as in Utah, where we have *Thelypodiopsis argillacea*, *Glaucocarpum suffrutescens*, and *Crytantha barnebyi* in the Uinta Basin that occur in very similar habitats that are close together. This could be a neat package, and we may incorporate *Cryptantha grahamii*, which is nearby, and *Penstemon grahamii* so you could have four or five in one package. Now that they have the new regulations for conducting public hearings, one public hearing would take care of all of those.

Q. Ninety percent of the projects are being completed without an inventory. Isn't that contrary to the law?

A. Not really. It's contrary to in-house policy, but not to law. The law, of course, is only for listed species. We have few listed species, and the projects, of course, are not impacting those. Those are on our priority list. If they were impacted, we wouldn't allow the projects to continue.

TABLE 2. State programs for T/E plants in the western United States.

	Cooperative Agreements Under Sec. 6 of the ESA		Other State Programs	
States*	Animals	Plants	Heritage	Research natural areas
Arizona	None	None	Signature stage	Yes, inactive
California	Qualified on 6/23/76	None	Signature stage	Active program
Colorado	Qualified on 6/23/76	None	Proposal stage	?
Idaho	Trying to qualify	None	Proposal	Idaho Natural Areas Coord. Committee
New Mexico	Qualified on 6/23/76	None	Established in 1975, now handled by state fish and game	None
Nevada	None	None	None	None
Oregon	None	None	Established in 1973	State Natural Areas Preserves Committee
Utah	Trying to qualify	Proposal submitted by state on 5/04/77	None	
Washington	Qualified on 6/23/76	Proposal submitted in 1976	Started Fall 1977	Natural Areas Advisory Preserve Committee
Wyoming	None	Proposal submitted by state on 2/11/75	Established in 1978	?
Montana reviewed	State program being reviewed by FWS	State program being	Proposal State	?

*23 states have qualified for cooperative agreement for wildlife programs.

STRATEGIES FOR PRESERVATION OF RARE PLANTS AND ANIMALS

G. Ledyard Stebbins[1]

ABSTRACT.— Human preservation of endangered species apparently commenced prior to recorded history with *Ginks biloba*, in China, a tree now known only under cultivation. A number of species have become extinct because man either failed to recognize their value or did not act quickly enough to preserve them even when their value was appreciated. A philosophy of conservation must be based upon cooperation with others looking to the future. Appropriate strategies that could be adapted from the military to achieve the objectives of species conservation include: (1) Know your enemy, his strengths and weaknesses, and the tactics he is likely to employ. (2) Inferior forces cannot hope to annihilate or completely neutralize an enemy, but can deflect him from his course. (3) If you have limited manpower, don't try to do too many things at once; concentrate on primary objectives. (4) Seek the most powerful allies you can find and learn to cooperate with them as nearly on their own terms as is compatable with your objectives. (5) Soften the enemy by harrassment, when possible, before beginning the final attack. (6) Make use of all the time that is available; do not risk defeat by premature attack. (7) Never give in as long as there is hope. (8) The most important principle of all, never underestimate what you are doing.

The first rare species to have been preserved by humans was *Ginkgo biloba*, the Chinese Maiden Hair Tree. Nobody has ever seen it as a wild tree. The first Europeans to see and name it found it in the courtyards of the temples of China. Fossils indicate that during the Tertiary period, 30 or more million years ago, it was widespread through the Northern Hemisphere, but by the time humans had appeared on the scene it was already confined to China. Where did it grow as a native and why was it preserved in cultivation? A possible answer to these questions is provided by clues given me by a good scientific friend of mine, the late Edgar Anderson. He had one of the most remarkable perceptions for understanding cultivated plants and their relationships to their wild ancestors. He said, "Ledyard, have you ever thought about this fact—that the trees which are most successful along the streets of our cities are those which are native to the banks of great rivers or deltas? This is because a river tree is used to being flooded at one season and parched dry at another season, having heavy soil dumped on it, and big logs fall over it, receiving all the punishment that a tree gets under street conditions." *Ginkgo* is such a tree. I was impressed by this many years ago when I was working at Columbia University in a laboratory suite on the eighth floor of the biology building there. I looked out every morning at the top of the Ginkgo tree eight stories above the courtyard where that tree had been planted. In the middle of New York City, it was certainly a very successful tree.

The Chinese plain is traversed by two huge rivers, the Yangtse and the Hoang Ho (the Yellow River). Although the climate of China is a forest climate, those plains are now completely denuded of native trees. Cultivation extends right to the edges of the rivers. Presumably those forests were cut down long before the Christian Era. My speculation is that Ginkgo was an element in ancient Chinese riparian forests. When the forests were being cut down, the priests of the temples thought it an unusual tree, and having medicinal properties. They brought in the seeds and saved trees in the temple courtyards. They were the first conservationists I can think of. We come from a long and honorable lineage.

Nevertheless, the concept of conservation became almost extinct during the earlier centuries of our own millennium. The past 500 years have witnessed the most extensive extinction of animal species due to a single cause to have happened during a 500-year period throughout the evolutionary history of

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animals. That cause is human interference with nature. Among the well-known victims of human destruction are the dodo, the great auk, the passenger pigeon, the plains bison, the moas of New Zealand, the Asiatic lion, the European forest horse, and the native wild horses that formerly roamed the American plains. Many others could be mentioned. Must this destruction continue or can we stop it? Before considering means of reversing this trend, we must be fully aware of the problem we face. Our opponents are not merely a few greedy men who are out to make a fast buck in total disregard of other human values. We certainly must face and neutralize such enemies by any means available to us. In addition, we must realize that our efforts are running counter to a life-style that was adopted by prehumans long before our own species, *Homo sapiens*, came into existence. Recently acquired knowledge about human evolution suggests strongly the belief that when human ancestors left the shelter of the tropical forests that were their original homes and began to live by hunting game in savanna areas, they adopted, partly in a subconscious way, a life-style that was based upon two objectives: destroy or annihilate the enemy and exploit the resource. The first enemies of humanity were predators. Hence the extinction of the Asiatic lion a short time after the Christian Era and in very recent times, the destruction of the California grizzly bear, the symbol of our state, during the 19th century.

Many more species have become extinct as a result, either directly or indirectly, of the philosophy: exploit the resource. Before humans started to cultivate fields or domesticate animals, the resources were wild game animals as well as wild plants that provided edible seeds, fruits, and roots—consequently early exploitation of wild horses took place in most of their range. Anthropologists have uncovered, particularly in the new world, many sites suggesting that primitive humans drove horses over cliffs, slaughtering them wholesale, picking up the bodies of those they could carry and using them for food, hides, and other purposes. This to them was a normal way of life. The destruction of flightless, slow-moving island birds such as the dodo and the great auk by European sailors and the moas in New Zealand by colonizing Maori people came about as a natural result of a desire for fresh meat on the part of men who had been deprived of it for a very long time. Other species have become totally extinct or preserved only in cultivation or domestication because their existence involved competition with resources of agriculture or domestication. Ginkgo has already been mentioned. Another is probably the ancestor of domestic cattle. As is shown so beautifully in paintings made by men who lived in Europe from 15,000 to 20,000 years ago, wild bulls were hunted as game. Archaeological records suggest that the first domestication of cattle was connected with religious rites. Bearing curved horns that resembled a crescent moon, cattle were regarded by some ancient tribes as sacred to the moon goddess. Sacred bulls of ancient Crete are well known to history, and, in India, sacred cows that cannot be killed still cause trouble. The expression "holy cow" is more than a casual bit of modern slang. It follows a long and venerable history. Domestication of cattle was one cause for the near extinction of wild animals. A beast as strong as a bull could be handled only if reasonably tame, yet whenever cows belonging to herds of domestic cattle were covered by wild bulls and produced calves from those bulls, genes for wildness introduced in this fashion must have counteracted the effects of primitive husbandmen to breed tractable herds. Wild cattle became not only a resource to be exploited, but also enemies to domestication. Modern history gives us similar examples of species that have become extinct or nearly so because of competition with various kinds of human efforts. The senseless slaughter of plains bison and passenger pigeons during the last century were not the only cause for the extinction of these species. Nesting grounds for the passenger pigeon were in rich bottom lands highly suitable for agriculture. Farm produce was regarded not only by the farmers themselves, but by everybody as more important than nests of pigeons. The buffalo competed with both cattle and dry farmers. Once the prairies were fenced in, the wanderers could no longer survive because their basic way of life had become impossible. More recently, plant species have become extinct because

growing cities have destroyed their habitat. Of two species that once grew only within the crowded city limits of San Francisco, one of them, *Sanicula maritima*, is completely extinct and another, *Arctostaphylas franciscana*, the San Fransisco Manzanita, is represented by a single wild shrub plus many in gardens.

These examples should teach us the following lesson: the main barrier to preserving our priceless heritage of rare animals and plants is not human greed. It is, rather, the natural tendency for people of all kinds to be shortsighted and to prefer to satisfy immediate needs rather than long-term benefits, particularly those which will be enjoyed only by their progeny of successors.

Moreover, conservationists are allied with a whole series of people who realize the need for reversing a life-style that has dominated humanity for over a million years. Annihilation and liquidation must be replaced by collaboration, or at least tolerance on all fronts. Exploitation must be replaced by conservation. The future existence of humanity depends on the success of efforts toward this reversal. Saving rare plants and animals is a small but highly significant part of mankind's vital efforts to survive during the coming centuries.

From the above considerations, a philosophy of conservation must be based more upon cooperation with others and looking toward the future. Education that might convert apathy into a true realization of the problem is preferable to a direct attack on an enemy, who is painted in black colors of uncompromising greed. Conservation is a form of politics, whether we like it or not. In a democracy or in a community of free nations, political action, especially when it is practiced of necessity by a small minority, depends for its success on adopting and exploiting to the limit strategies that are appropriate for each particular goal. The following well-known military strategies are particularly appropriate for conservationists who are seeking to preserve rare animals and plants. First, know your enemy, his strengths and weaknesses, and the tactics he is likely to employ. Potential enemies are any group of people who for reasons that may seem to be completely valid and justifiable are likely to destroy rare plants and animals and their natural habitat. Among them are people engaged in agriculture, livestock raising, operators of mines or quarries, prospectors, urban and suburban developers, developers of mass recreational facilities such as golf courses and ski slopes, and conservationists who believe the greatest need for future civilizations is water backed up in giant dams and water power projects. Each of these groups is armed with verbal weapons that may appear, on the surface, to be equally or more powerful than any of those in our arsenal.

The growing population needs more food. New resources of minerals and energy provided by coal, oil, and gas are vital to the nation's growing economy. The greatest need of the United States is more and better housing. Recreational development such as golf courses and ski slopes make life more enjoyable for millions. The rare plants and rare animals of the wilderness can be appreciated and enjoyed only by a small cult of nature lovers. The realistic way to provide for future generations is to build dams that will make more water and power available to people. All of these arguments sound logical, realistic, and incontrovertible. In a way they are. Attempts to refute them directly will certainly end in failure. Our strategy must be to recognize the partial validity of these and similar arguments. We must work around them, not try to overthrow them.

The second principle is: inferior forces cannot hope to annihilate or completely neutralize an enemy, but they can deflect the enemy from its course. On this basis, reasonable answers to the arguments mentioned above could be found. Surely more food, minerals, energy resources, and housing are needed, but with few exceptions these can be had by developments that do not destroy precious and irreplacable habitats and the native species they contain. The same can be said even more justifiably about the development of golf courses and ski slopes. As a matter of fact, I have taken part in opposition to development projects that are ill advised and ill conceived from a strictly economical point of view, regardless of conservation. Opposition from conservationists in those cases called attention to the unsound nature of these projects and, by causing them to be abandoned,

saved the developers or their innocent clients from economic embarrassment or possible disaster.

One of these is located in the north coast ranges of California. It was a proposed resort development on the shore of Boggs Lake, a large, vernal pool. In April or May, during the wet season, Boggs Lake is a sheet of blue, limpid water almost a mile in diameter surrounded by gently sloping gravelly beaches, behind which is a cool pine forest. Situated in the mountains almost 3000 feet above level, far from the nearest city or freeway, it would seem to be an ideal place for a hideaway where a cool forest glade and pure mountain water could be enjoyed. That description, and accompanying photos used by developers were based only on its spring condition. Its appearance, however, is highly deceptive. Boggs has no spring-fed inlet and is exposed continuously for five months throughout the California summer to a hot, dry sun. If one, therefore, visits this "lake" in August or September, the former lake has become a dry and dusty flat with a few soggy places in its center. Pine forests are still there, but they too have become hot and dry and present a continuous fire hazard.

Pools of this kind usually harbor several rare and endemic species. Boggs Lake is one of the best of this kind for botanical research. When members of the California Native Plant Society heard about a proposed resort planned along its shores, we went in great number to a hearing in the Lake County Courthouse to present our views. Before doing so, we took the trouble to walk around the area carefully and acquired a greater familiarity with the terrain than had the developers. Their publicity was based chiefly upon an airplane survey. Our view of the situation was strong enough to dissuade both the county supervisors and the developers from continuing the project. Boggs Lake was then acquired by the Nature Conservancy and its unique habitat is premanently preserved.

The third principle is, if you have limited manpower, don't try to do too many things at once. Concentrate on primary objectives. In terms of conservation strategy, do not spend valuable time on every species that is rare and local. Most of the rare species that live in national parks, state parks, wilderness areas, that have been set aside by the national park and similar privately controlled areas, need only occasional monitoring to see that provisions and rules for preservation are being carried out. Sometimes the officials need to be informed. I remember an example of a grass in the Sierra Nevada, a rare species, *Stipa latiglumis*, known from only about three localities. I had a suspicion about its origin. I suspected that it evolved in what now is a genetically familiar fashion: crossing between two other species of *Stipa* and doubling the chromosome number: an allopolyploid. The most accessible place for this species, according to herbarium labels, was Lost Arrow Camp in Yosemite Valley. In Yosemite National Park, as in other parks, a collecting permit is required. Collecting permits always say in very large capitals, NO COLLECTING OF ANY KIND IS PERMITTED ON THE FLOOR OF THE VALLEY. Nevertheless, I went to the park naturalist's office to ask for a permit. When I explained what I wanted, the park naturalist himself received me. He said, "Where does it grow in the valley?"

"The labels say Lost Arrow Campground."

"This is where the government center is built."

"Do you think there are any native areas here?"

"I think I know them pretty well, but I don't think you'll find anything unusual here at all."

"May I look? And if I find it here, may I collect it?"

"Well, I guess you can."

We started looking. We found it in the front yard of the private residence of the park naturalist himself. Its allopolyploid nature was demonstrated by Dr. Richard Pohl.

Other rare species, not in the national parks or preserved areas, nevertheless grow in such inaccessible spots that they are very unlikely to be destroyed. An example is a species of the genus *Eupatorium* that many years ago I discovered on a north-facing limestone cliff near Lake Shasta. *Eupatorium shastensis* is always perched on cliffs, and 80 percent of the plants of it are so high up on the cliffs that no one can reach them except by specialized rock climbing techniques. There is danger, possibly, from prospecting

or blasting of these limestone cliffs, except for the fact that they are in very rugged terrain, one of them isolated from any highway by the waters of Lake Shasta and the other on the summit of a very rugged mountain. Bringing in equipment to mine these areas would be extremely expensive. Because it is on their land, the Forest Service knows about it and I believe will not issue permits for prospectors or mining on these rather unusual limestone cliffs. This case requires monitoring, even if there is no formal preservation.

General applications of this strategy, I believe, is to keep lists of rare and endangered species as short as practicable, to pay as much attention as possible to the amount of danger and the nature of the danger to which a species might be exposed and to determine actual rarity in terms of space occupied and actual numbers of individuals in each population. Government officials and leaders of general conservationist organizations, such as the Sierra Club, should not be presented with lists of two or three hundred species with unfamiliar names. I suspect that in many instances these are filed in some cabinet, which a secretary might open every six months or so. Here is a situation where the more we know about potential and imminent danger, the better off we are.

The fourth principle is to seek the most powerful allies you can find and learn to cooperate with them on as nearly their own terms as is compatible with your objectives. My happiest experience with powerful allies resulted in partial preservation in an area that for 25 years previously had been very dear to my heart. This is a little-known portion of the fabulously scenic Monterey Peninsula on the coast of central California. That area, a small, ancient "raised beach" millions of years old (Pliocene), is underlaid by a sterile, hard, and impervious "hard pan" soil. Its plant communities contain so many problems in evolution and plant geography that I have nicknamed it "Evolution Hill." Its most distinctive tree species are the Bishop pine and the narrowly endemic, rare dwarf, Gowen cypress. Each time I have taken students to this area it has given me cause for apprehension. We could traverse by foot a network of trails and rough roads. The owners had the trees and brush cut so that they could very easily be converted into paved streets and the whole place put into a resort development. Ownership is in the hands of an exclusive multimillion dollar organization, Del Monte Properties, which was then the fiefdom of one of the most prominent citizens of northern California, Samuel F. B. Morse. One day during the 1950s I obtained an appointment with Mr. Morse to discuss the future of Evolution Hill. The great man was polite and cordial. He said that he too was much interested in saving the area and to see that it remained preserved as long as he remained in control. He could not, however, make commitments that would tie the hands of his successors. Mr. Morse at that time was in his late seventies and he had clearly given me only a temporary stay of execution. Several years later, after Mr. Morse's death, the blow fell. I received a telephone call from a prominent resident of the peninsula, the director of a nearby laboratory. He said, "I want you to come down to Salinas to attend a meeting of the County Planning Commission. The new director of Del Monte, who used to be vice-president of the Corning Glass Works, wants to start a sand quarry for glass in the forest right behind our house." I realized at once that Evolution Hill was in danger, but also that we members of the California Native Plant Society had powerful allies. Several of the most wealthy and prominent homeowners who had bought and built in the forest in order to have quiet solitude with undisturbed woodlands for hiking and horseback riding felt that their life-style was severely threatened and that the hundreds of thousands of dollars they had invested in their homes might go down the drain. The result of the first hearing was noncommital, but the stay of execution was maintained. No permit to quarry was issued. We then organized a joint fact-finding site visit attended by more than 100 members of the Native Plant Society plus several homeowners. Such an event deserved and received good newspaper publicity in the area. Hearings and litigation continued for about two years. Finally the quarry-minded individuals from the Del Monte Company gave up the sponge. They donated a portion of the hill to the county to be set aside as the S.F.B. Morse Preserve and

agreed not to quarry for sand in an area near the established homes. We would have preferred to see the preservation of all of Evolution Hill, and this may still be possible. Ten years after this partial victory, it is still as I first saw it; no homes have been built in the area.

The fifth principle of strategy: if possible, soften the enemy by harrassment before beginning the final attack. This principle is well illustrated by an experience we had a few years ago in an endemic area in the Sierra Foothills, known as Pine Hill. This hill, 25 miles east of the state capitol of Sacramento, about 2000 feet high, has a number of endemic species. The most spectacular of these is a flannel bush, *Fremontodendron decumbens*, described by Dr. Robert Lloyd. It is noted for its prostrate habit and its copper-colored flowers, where most flannel bushes have bright yellow flowers. It is a very distinctive species, not known anywhere except on Pine Hill. I say with some confidence that my friends and I have combed over every hill in the neighborhood that could possibly hold it and we have never found it, so I'm certain the central ridge of Pine Hill is the only place where this shrub grows.

One day a member of the Native Plant Society visited Pine Hill only to find that the Forest Service, in order to construct a fire break, had cut down almost all of the shrub of *Fremontodendron*, and it looked as if it was gone. His reaction was immediate and positive. He wrote a strongly worded article that was soon published in our society's journal. The article brought a flood of letters from outraged members of the Native Plant Society to the office desk of the district manager. That was in May. In October I got a letter from a friend in the nearest town, Placerville: "Ledyard, I want you to come. I've got to go out with the ranger to Pine Hill." Why? "Because they want to put in a little powerplant, about 10 × 20 feet and they want to do it without having all the flack that we gave them on the fire break." So we went up there and we told them where to put it, a place where there were almost no plants. Soon after, we were able to enlist the powerful ally. The husband of the secretary of our Sacramento chapter of the Native Plant Society, Warner Marsh, had been in the Sacramento office of the State Forest Service for many years and was highly respected by all personnel in that service. So, Warner went out with one or two other people and the ranger and put a little pink ribbon on every shrub of the *Fremontodendron*. Fortunately, it is quite a resilient shrub. Cutting down the branches didn't destroy the roots, and so new branches came up. They're back again and now the California State Forest Service isn't going to disturb them. We are having other problems with Pine Hill because of changes in the state government organization, but we're still very optimistic that the whole area will be preserved.

The sixth principle of strategy is to make use of all the time that is available. Do not risk defeat by premature attack. Many conservationists who are aware that an unusual habitat is threatened by mining, quarrying, development, or some other way, tend to magnify the threat and particularly its immediacy. Sometimes this attitude is justified and necessary; other times it is not. Surely, if the developer is known to have his eyes on one of our favorite spots, we must act quickly with all resources at our command. Nevertheless, we cannot be stampeded by a potential danger which may not be realized for some time. Here again precise knowledge of the danger that threatens a rare species or community is of the utmost importance.

The seventh principle is never give in as long as there is hope. One can lose several battles but still win the campaign. The last two principles are well illustrated by the campaign to save the Ione Manzanita area on the eastern margin of California's central valley, one of the most dramatic of California's ecological islands. I call it an ecological island because the soil is so different from the surrounding soils that the species living there are isolated as if they were on an oceanic island surrounded by a sea of grass and oaks. Another inhabitant of the barrens is a species of buckwheat, *Eriogenum opricum*, described about 25 years ago by J. T. Howell.

When the California Native Plant Society was formed, one of our objectives I thought of almost immediately was saving Ione Manzanita, so a group of us went to the Amador County Courthouse first to find out who owned it. The results were not encouraging.

The whole area belongs to a syndicate controlled by a large San Francisco bank, which leases land to miners and quarriers because there is a clay of extremely high value. When we approached one of the officials of this company, we got a very emphatic reply, "We'll mine every blank blank cubic foot of that sand and clay and we dare you blank blank s. o. b.'s to stop us."

Somewhat later, we were still trying to find a way around them and went on a Sunday when we thought nobody would be there to look for another spot for the *Eriogonum apricum*. We ran into some people who turned out to be miners who were not mining on Sunday, but were hunting quail or something like that. They said, "What are you doing in our place?" We explained what we were doing. "You better get off. We're honest miners and we've been working this for 20 years. This place is full of rattlesnakes and I wish there were twice as many of them to keep you blank blank blanks from going on to it." Well we haven't given up. We've had articles in our journals. We've had publicity wherever we could find it. We've discussed it with the California Department of Parks and Recreation and other groups, and we have gained some allies. Meanwhile the quarries that existed for some time are still there and still working, but they haven't invaded any more territory than they had when we first started in 1966. So while there's life there is hope.

(NOTE: As this article was going to press, I received a welcome announcement: The central heart of the Ione Manzanita area has been purchased by the Nature Conservancy.)

The eighth and last principle—the most important principle of all—never underrate the importance of what you are doing. Human civilization is built on two great pillars. A pillar of knowledge and a pillar of beauty and its aesthetic appreciation, whether it be the beauty of nature, artistic creation, or the beauty of the spirit. Drs. Lovejoy and Clement this morning showed us part of a worldwide effort to save humanity from its own destruction. Fountains of knowledge can be bound up in the most ugly and unattractive weeds we are trying to save.

A plant known only in a few suburban areas, which is now severely threatened, is a tar weed known as *Holocarphra macradenia*. Now tar weeds are among the nastiest weeds in California pastures. To try and tell a rancher that you want to save a tar weed is just like telling him to stop drinking beer. Well, it so happens that this species was part of a large-scale research project carried on by I. Clausen and D. D. Keck 25 or 30 years ago. They discovered that what the taxonomists had called two species are actually four morphologically recognizable ones. Among those four species, hybrids between almost any collections from two different localities were sterile or couldn't be made. In other words, hiding under first two and then four species is a whole series of little narrow endemic species, the nature of which is associated with chromosomal difference. In our quest for understanding the mechanisms of the origin of species, the tarweeds, including *Holocarpha macradenia*, could be a key group. Now we will have to resist the desire to succumb to the developers and keep the species alive, at least under cultivation. After all, the habitat will be gone anyway. The place where it has been known for the last 50 years is in association with wild oats and other introduced species. Its prehuman habitat was gone long ago. This is an example of a humble sticky, smelly, nasty weed which could be a gold mine of scientific information.

Now we should then come to the aesthetic value. My illustrations cannot equal the beauty you saw in the booklet of the National Wildlife Federation we all received this morning. I'll show finally just two slides which give a modest impression of the beauty of plant species. One is a Monterey cypress, growing on the granite cliffs facing the blue Pacific Ocean, with its picturesque branches and trunk growing out of solid granite. The other is a pure white flower of the California rose mallow centered with the deep maroon spot in the middle of the flower, growing in the hot valley in the middle of the summer.

STRATEGIES FOR PRESERVATION OF RARE PLANTS

Arthur H. Holmgren[1]

Abstract.— Preservation of the habitat is the only logical strategy to save endangered species from early extinction. Ecological amplitudes of rare species are very narrow, so transplantation to such alien sites as botanical gardens is not a solution. Protection may not be the answer. We must learn as much as we can about the biology of the species in question, in the field and under laboratory conditions. The first steps must be to determine the distribution. This would be followed by analysis of soils by means of physical and chemical studies. Pollination ecology, associated species, phenological records, and genetic and cytological studies must be a part of the biological studies. Such studies would require teamwork by qualified botanists.

I suspect I was asked to take this assignment because, as several of you know, I have cultivated many of our western native plant species. Most of these plants were introduced into my gardens so I could have laboratory material for my taxonomy classes. I had great success with *Penstemons* and at one time I had 33 species in this genus. Many of my *Penstemons* hybridized under prolonged flowering conditions in my gardens until it was difficult or nearly impossible to determine parents of most of my hybrids. Some of my introductions in other genera became troublesome weeds. These are not the kinds of species we are concerned with in this symposium.

I will devote my time to strategies for preservation of rare plants. My answer and only logical strategy is to preserve the habitat of the threatened and endangered species so that we may save them from early extinction. Species inevitably become extinct, in times past by natural forces, but in recent times greatly accelerated by man's destructive activities.

Extant knowledge of rare species indicates that ecological amplitudes are very narrow and thus transplantation to such alien sites as botanical gardens is not a solution. And still, *Franklinia alatamaha* Marsh was preserved in cultivation. The lost camellia or Franklin tree, originally from someplace in the coastal plain of Georgia, was discovered by John and William Bartram in 1765 and has not been seen in its native place since 1790. Many botanists have searched long and hard for the lost camellia. Dr. Ritchie Bell of the Botany Department at the University of North Carolina has made several expeditions with graduate students in search for the lost camellia that has been in cultivation for nearly 200 years.

In the absence of hard data, habitat preservation is the only option open, and it is increasingly at hazard because not even the scientific community understands the problems. Habitat preservation is seen as a powerful threatening tool to the public at large and especially to those who are anxious to develop our natural resources. Elected office holders and seekers are afraid to line up with the biologist who sees the need to preserve habitats of threatened and endangered species. We have no idea yet how much area to protect or even if protection is the answer.

Two species come to mind that thrive in disturbed sites. *Astragalus paysonii* (Rydb.) Barneby is usually found in burned-over areas in Wyoming and *Mertensia toyabensis* Macbr. thrives in similar habitats in the Toiyabe Range in Lander County, Nevada. Many species make a living in disturbed sites, but it is unusual to find rare species in such habitats. Perhaps more fieldwork will show that the two species mentioned here are not as rare as we have thought.

Dr. Howard S. Irwin, president of the New York Botanical Garden, said in a letter to me

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dated 16 October 1978: "The most desperate need is a federal program that would encourage students to study the biology of species' rarity, more or less in the manner followed by Dr. Lazarus Walter Macior at Akron University in investigating the Furbish lousewort."

I contacted Dr. Macior and received a prompt reply dated 14 November 1978. Dr. Macior enclosed a copy of his manuscript which will appear in the October-December 1978 issue of the *Bulletin of the Torrey Botanical Club*. All papers published in the *Bulletin of the Torrey Botanical Club* are copyrighted, so the manuscript was sent to me for my personal use only. Dr. Macior's work with the Furbish lousewort will certainly become a model for experimental studies on rare species.

The first step in a strategy for preserving rare plants must be to learn as much as possible about them in the field and under controlled conditions in the laboratory. Every effort must be made to determine the distribution of the taxon in question. *Smelowskia holmgrenii* Rollins was thought to be confined to one rock prominence in the Toquima Range, but Sherel Goodrich discovered that this unusual species was actually more common in the Toiyabe Range to the west. The known distribution at this writing includes four stations in the Toquima Range and 10 populations in the Toiyabe Range, so the species is not considered to be in the precarious situation suspected prior to the 1978 field season. This unusual mustard is a distinctive species, and, as is true so many times in this family, species are easier to recognize than the problem of assigning them to genera. I still have difficulty thinking of this species as belonging to the genus *Smelowskia*. To me, it seems to have closer affinities with the genus *Braya*, far to the north. It may turn out that we have a new genus. *Arabis shockleyi* Munz is another species that may turn out to be more common than we have thought. Only a few widely scattered collections have been made from Tooele County, Utah, to the San Bernardino Mountains in California. The paucity of collections probably illustrates how poorly some of our desert ranges are known.

Detailed field studies would vary to some extent with different species. The *Smelowskia* of central Nevada is found in crevices of andesite rocks, and future studies on this species may show that it has a preference for this kind of a substrate. *Arctomecon humilis* Coville and *A. californica* Torrey and Fremont probably require gypsum soils, often referred to as "gumbo" clay.

Detailed biological studies would begin after the distribution of the species has been determined. Biological studies of rare species would investigate the ecological adaptations of the species as to edaphic factors and biotic environment. Soil samples would be taken from many sites and thoroughly analyzed with every sophisticated chemical and physical means we know. Weather records would be analyzed or gathered. Total precipitation means little unless we know the distribution throughout the year. Climatic characteristics in a broad sense would also include solar radiation and temperature records.

Pollination ecology may be a key as to why a species is rare and perhaps even on the verge of becoming extinct. The loss of a pollinator through spray programs may place a species in imminent danger of becoming extinct.

Phenological records should be kept and associated species recorded. What are the requirements for seed germination? Much remains to be learned about seed germination and especially for rare species. Under what conditions is flowering initiated? How soon after flowering are fruits matured, and what is the mode of seed dissemination? Are certain species usually associated with a taxon we are studying, or is a niche so inhospitable that our species has the habitat without a competitor?

Cytological studies would help in possibly determining closely related species. Dr. James Reveal and I prepared a paper several years ago on *Gilia caespitosa* A. Gray that was never submitted for publication. The chromosome number of this rare and restricted species was determined to be the same as the wide-ranging and highly variable *G. subnuda* A. Gray, $2n = 16$. *Gilia caespitosa* is restricted to white, decomposed sandstone one mile south of Teasdale in Wayne County, Utah. Dr. Dieter H. Wilken has prepared a fine paper on *G. caespitosa* in much more de-

tail, "The Status of *Gilia caespitosa* A. Gray (Polemoniaceae)," which has been accepted for publication in Madroño. Dr. Wilken has concluded that *G. caespitosa* has a close relationship with *G. subnuda*. Reduced specimens of *G. subnuda* are very similar to the uniform specimens of *G. caespitosa*. Dr. Wilken suggests that *G. caespitosa* may represent one of he more primitive elements within *Gilia*. In my Honor Lecture in 1977 at Utah State University in Logan, Utah, I pointed out that this beautiful little perennial may have arisen from an extreme biotype of the variable and common *G. subnuda*. If a widespread species becomes established in an unusual edaphic situation, it will carry only a small part of the genetic variability of the original species. Inbreeding and random fixation will tend further to make this insular population more uniform and still more different from the ancestors as the years of isolation continue. The individual plants of this beautiful species appear to be as nearly genetically alike as separated parts of a clone. It does not seem logical that this species is a senescent species. It probably evolved where it is found today and adapted to a single ecological niche. It seems unlikely that it occupied a larger area in past times.

The biological studies outlined above are all a part of the first phase in learning about rare species, but the studies obviously do not stop here. If the species is threatened in part of its range, some natural populations must be preserved in situ for further study. This is especially true for the three species of *Arctomecon*. Each species is confined to a precarious habitat and all three are fast disappearing. The fact that requirements for seed germination are not known and that the plants cannot be transplanted make it imperative that these plants be studied in situ. Housing developments, trail bikes, and gypsum processing plants doom at least two of these bear poppies. Oh, yes, I had better not forget to point a finger at the plant taxonomist. I was appalled when I discovered how many specimens we had in the Intermoutain Herbarium. It is well known that numbers of specimens in a herbarium are no indication of rarity.

Another step in preserving a rare species may be in attempting to cultivate plants in identical habitats or very similar to the original ones. This would involve attempts to germinate seeds for transplanting of garden or greenhouse-grown plants and transplanting growing plants from natural habitats. This does not excite me, as we have attempted to grow several rare species. Leila M. Shultz, curator of the Intermountain Herbarium, succeeded in germinating seeds of the rare *Sphaeromeria ruthiae* Holmgren, Shultz, and Lowrey from Zion National Park. At the present time, we have two potted plants growing in my home greenhouse in soil from the type locality. After two years of vacillating from "Looking good" to "Will they make it?" I begin to wonder if my specimens will ever flower. So many things come to mind. What about solar radiation, length of day, and on and on? I have successfully transplanted and multiplied *Cypripedium calceolus* L. from the mouth of the Logan Canyon that was in the way of a new home. I have divided the clumps several times and even moved the entire population when we moved from our old Logan home to a site near the base of the mountain just north of the mouth of Logan Canyon. There are more plants today in my garden than the original population contained 35 years ago. I have thought of moving a few plants to sites in Logan Canyon to habitats that would probably support this lovely orchid, but I hesitate when I think of the pressure of every foot of bank area along Logan River by fishermen. The plants I am growing represent the only known living plants of this species in Utah. Extirpation would once again remove a species from the wild that ranged from Logan to Provo when the Mormon pioneers came to Utah.

I have attempted to grow the rare heterostylous *Primula maguirei* Williams that is known only from a nine-mile stretch in Logan Canyon and consisting of only seven known populations. Plants flowered the first year and emerged the second year without flowering, and, after languishing for a short time, disappeared from my garden spot, which I had thought was quite similar to the canyon habitats. I hope to see a graduate student work out the biology of *Primula maguirei* in the near future. Howard Irwin reports that the New York Botanical Garden

recently got a grant to conduct studies of the New York Monkshood, *Aconitum novaborescense* A. Gray, initially to determine its distribution and also to get some biological study underway. This unusual monkshood is presently known from a few localities. This is the way to go, and sometime in the future we will have hard data to give us a better understanding of past and present histories of floras and species.

The most important strategy of all has to be for us to win public support and thereby gain support of elected officials on all levels. Unless we gain this support, there will be no funding for the work that is just beginning.

We have made gains since Earth Day, 22 April 1970, but in other important ways, we have lost ground (no pun intended here). The radical rhetoric of street protests has been replaced by legal briefs. There are probably more than 8 million members of environmental groups who make contributions totaling nearly 70 million dollars a year. The Audubon Society and Sierra Club were the first of the conservation groups, but they have been joined by many more. State native plant societies are organizing, with several new societies each year. We know of the accomplishments in California and what the potentialities are. We have just organized a Utah Native Plant Society. This is the way we can get our message to the state and local levels.

I share the anxiety of Howard Irwin, Walt Macior, and Dieter Wilken in preserving rare species; but, in the meantime, we cannot be sympathetic with those who would preserve them only as instruments for political strategy. Those who have taken strong stands pro or con without sufficient knowledge have hurt our cause. In the meantime, let's study our rare species intently with qualified, professional botanists.

QUESTIONS TO DR. HOLMGREN

Q. There is a big problem in that information available is not keeping up with the demand. The gentleman from the Forest Service said they had 200 cited to survey and funds to do 20. The problem is even greater in private industry. The company proposes a project and requires a survey and the information is just not generally available. Do you foresee a way out of that dilemma?

A. I just don't see a way out of it. In fact, very often we see proposals or requests for proposals come across our desks and we are supposed to have something in on it a week before the proposals came to us. Sometimes we have about six weeks to work this out. There is no way we can do it. To pretend that some of these things can be done in such a hurry is not being honest with the problems that are at hand. It is going to take some time. Very often these things have been under planning stages for a long, long time, but the problems do not come to us until the last minute. No one plans a $100 million plant without having gone through a lot of planning, and then in the final stages the requests come across our desks. What can we do? It is going to take some time.

Comment: The Forest Service is developing a policy now that would require all external organizations proposing projects on Forest Service land to hire a professional botanist to inspect the project for T/E species, so we'll get a lot of these covered in that way.

Q. Does the cultivation of plants and plant planning hold a better opportunity than we have experienced with animals?

A. Sometimes it does. Janice Beetley brought in some seeds of *Arctomecon*, and she succeeded in germinating them but they never flowered for her. We know that is a genus where transplanting is an impossibility. It surprises me because so many members of the poppy family can be grown from cuttings, but this particular one defies that. I used to think I could grow anything if I knew the right witchcraft, but I've discovered there are all degrees of absolute success, to the point where you have weeds coming along in your garden to the point of absolute failure on the other end. In my years of experience with native plants, I could plug in something all along the way so that I would go imperceptibly from complete success to failure.

Comment: A comment really to the gentleman's earlier comment. I believe there are a growing number of industrial concerns who recognize the problem of endangered species to the point that they would much rather incorporate biological knowledge earlier in the planning process than face litigation later on. In this way I think there is progress being made in this area.

A. I'm sure there is. I think that is one of the good things about some of the problems we've had along the way that these people have discovered. As they begin to plan, this is one part that has to be in the planning stages right from the very beginning. I think there were references to that in talks we heard yesterday. People are beginning to come to some of these agencies, and Doug Day has had several people come to him and ask for help as they were beginning to plan a study. I think we are going to have more of that to a point where I hope that finally we can get the public on our side. It's going to be a long education, but every day when I pick up newspapers now I read articles by different authors, DeLong and several others, who are writing very well-written essays on the problems we are now facing.

Q. One thing I'm surprised no one has mentioned. I'd like to know if the Fish and Wildlife Service has contacted either BYU or the Intermountain Herbarium. At the present time Stan Welsh has computerized all the herbaria for Colorado, Wyoming, North Canada, and North Dakota. Listed in their computer program is every sample surveyed of those herbaria. Any agency or industry person interested in developing a project need simply place a phone call to Fort Collins asking them to print the species list. It has a tremendous option on it. Included on it are all the rare and endangered species in a specific geographic area and I've heard rumors from workshops held in Fort Collins that they plan on expanding this. Have you been contacted about that?

A. I haven't. Have you, Leila Shultz?

Comment: No, but I do have a comment on it. Herbaria standardly have 40 to 70 percent misidentifications and so, as good as the information is, it's nice to have it available. But if you want lots of misinformation you can get it quick.

A. Yes, there are so many people who will look at a herbarium label and the identification on that becomes the gospel truth. We know. We get plants from other institutions that are not even in the right genus, and sometimes the species is a long ways away (but not from the BYU). We're glad we have such good working relationships with all universities.

Comment: I have talked to Colorado State about possibly getting on this sytem, and, although there are misidentifications, I think, where you have the computer printout, if something comes out in the distribution very different from what you expect, it comes to your attention in a hurry. I think there is good potential in it.

A. I was trying to get Leila's attention because for the last several years she has been listed as the assistant curator, but I'll have you all know that she is the curator. She's done it all and I've been happy, but sometimes it has given her more than a person ought to carry.

Comment: I have one comment here. Perhaps the information or the lack of information here with regard to the private industries approach to endangered and threatened plants needs to be traded. Until now it hasn't been, so I will take it upon myself to give you my own professional view of it with regard to the private industries I have dealt with. Private industry is willing to cooperate with the endangered species program. They do not wish to interdict any of the endangered or threatened species. They are willing to do what is necessary in order that they may fall in place, but they do need to be able to survive the regulations so that they can carry on their businesses. The problem arises though, not with the private industries, but with the general public. The general public is the place where we really need to do our education job and not with the private industries. The private industries are ordinarily with us.

STRATEGIES FOR THE PRESERVATION OF RARE ANIMALS

Clayton M. White[1]

ABSTRACT.— Strategies used to enhance or help restore rare and endangered animal species are reviewed. No new strategies are presented, but rather a review of various levels at which programs can be initiated are indicated. Nearly 93 percent of the recognized endangered animals are vertebrates. Programs to help restore vertebrates can be aimed at either the habitat or the organism level. Habitat restoration or preservation is the more difficult to achieve and, accordingly, most strategies are aimed at the organism. Species, populations, or communities and ecosystems can be treated, but most often each requires a separate approach. Among organisms the species level attracts most of the enhancement effort because species are easier to understand and deal with. Numerous strategies are being tried with species, and several examples, such as the Aleutian Canada goose, Galapagos tortoise, a wingless undescribed orthropteran, and fish species requiring turbid water, are given. Populations or communities of animals are more difficult to work with, but some strategies such as faunal reserves are likely to be successful. A table listing 39 examples of endangered species from across the animal kingdom, along with the major reasons for their declines and currently working strategies or possible ones to help them recover, is presented.

This report reviews strategies used to enhance or help restore rare or endangered animal species, and, as such, the approaches are clearly different than most of the strategies reviewed by Holmgren (this volume) for plants. This report, however, is not intended to be an exhaustive review of all the various plans, mechanisms, or strategies that have been used with all animal species.

At the outset, it must be recognized that most ideas advanced thus far apply to vertebrates and are not necessarily applicable to invertebrates. In part, our knowledge of the population dynamics of many rare invertebrates lags behind that of the vertebrates. As pointed out earlier by Lovejoy (this volume), the invertebrates are also currently treated administratively in a different manner than vertebrates. Those animals officially recognized as rare or endangered by federal or international convention as of 1 December 1978 (U.S. Department of the Interior 1978) are in the following categories:

Mammals	281	Snails	8
Birds	214	Clams	25
Reptiles	68	Crustaceans	1
Amphibians	16	Insects	8
Fish	51		

The above total to 672 kinds, plus there are an additional 158 kinds proposed. Of those listed, about 74 percent are mammals and birds and nearly 93 percent are vertebrates.

Before approaching the topic of discussion, I think it fair to conclude that endangered species programs and concerns are mainly generated in affluent societies where people have the leisure time and the monies to consider such problems (cf. Smith 1976). Roland Clement (this volume), however, ironically pointed out that it is the affluent societies themselves which, because of their exploitive nature, have been the root of the causes of habitat destruction and thus species endangerment. The basic question seems to be "What will man as a species tolerate?" In nonaffluent regions they appear to tolerate considerable, even the loss of part of their faunal heritage. Myers (1971), in discussing the preservation of fauna in Uganda, has correctly pointed out that the wildlife heritage of that country is of international concern, and that the land should be developed, conserved, and managed in accordance with sound ecological principles. Sociological concerns also play an important role in such issues.

Another curious paradox is that the bald eagle (*Haliaeetus leucocephalus*), which we have declared as part of our heritage by af-

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fording it the status of the symbol of our country, is endangered. Similarly the quetzal (*Pharomachrus mocinno*) is endangered in Middle America, where it is represented on the coinage and is a national symbol in Guatemala (Lovejoy, this volume).

Levels of Organization

There are at least two major levels of organization from which strategies for preservation have been or can be approached, namely, (1) the habitat (environment) level and (2) the organism level.

The only clear way to preserve animals is, of course, to preserve or maintain habitat in large enough blocks of land to maintain the species diversity. This leads basically to the concept of the "megazoo" as developed by Sullivan and Shaffer (1975). Among others, Diamond (1975, 1976), Terborgh (1974), and Wilson and Willis (1975) also discuss the habitat approach to organism preservation and the strategies achieved by maintaining significantly large tracts of habitat.

The habitat and the organism level have rather different approaches. For example, zoological gardens may be used if simple preservation of the rare or endangered animal is desired (Conway 1967, 1978). Such preservation, however, can be and most frequently is independent of any approximation of habitat because the animals are simply bred and maintained in cages. Nonetheless, there are currently 26 species of rare mammals that have self-sustaining populations in zoos (Pinder and Barkham 1978). These represent one species of marsupial, 2 primates, 8 carnivors, 3 perissodactyles, and 12 artiodactyles. In some cases, there may be as many or more individuals in zoos than there are in the wild. The Asiatic lion has 96 in captivity and an estimated 177 in the wild, the Siberian tiger has about 450 in captivity and perhaps 200 in the wild, and the Pere David deer is extinct in the wild but about 777 remain in captivity (Pinder and Barkham 1978).

Before strategies for preservation can be formulated, it is necessary to determine the reasons for endangerment and that, in turn, may lead to a basic knowledge of the biology of the animal to be dealt with specifically. It is difficult to understand an animal's rareness when we don't understand its population dynamics (see Drury 1974 and Smith 1976). Simon (1969) discussed some of this when he described the status of 86 rare mammals in 33 countries; examples follow:

Peru —Vicuña (*Vicagna vicugna*): information inadequate and conflicting, field surveys needed.

Brazil —Thin-spined porcupine (*Chaetomys subspinosus*): little known about species beyond fact that range is restricted, deforestation modifying habitat, and field studies needed.

Morocco—Barbary hyaena (*Hyaena hyaena barbara*): status precarious, true position obscure, and studies needed.

Following Simon's (1969) assessment, Miller Rottman, and Taber (1973) studied the vicuña in South America and determined that the present stocks are occupying suboptimal habitat and that the carrying capacity of the present available habitat (in terms of preferred forage etc.) is about 10 times the present numbers. The current range is less well watered than the optimum range. Because the species need to water daily, the answer to improving the population status seems to lie in providing watering localities in areas where forage is adequate but no water exists. Aside from habitat improvement, hunting for fur also needs to be controlled.

It is surprising how little we know about the biology and evolutionary dynamics of even the most common species. Both the house sparrow (*Passer domesticus*) and European tree sparrow (*Passer montanus*) were introduced into the U.S. in the 1850s and 1870s, respectively (Kendeigh 1973). The house sparrow has become continent-wide, while the tree sparrow has remained in the general locality of St. Louis, where it was introduced. As a correlary, house and European tree sparrows were also introduced into Australia in the 1850s and 1860s, respectively (Frith 1977). The former species now covers more than one-third of the continent, but the latter has expanded to a few hundred kilometers between Melbourne and Sidney. These two examples both suggest that on the Amer-

ican and Australian continents some sort of competitive interaction or pressure which we don't understand is being exerted that is not operative in their native Eurasian range. We certainly do not understand their behavioral interactions.

If we now turn to the animal level as the working unit, there can be, once again, an organizational breakdown for preservation or restoration as follows (the ecosystem or community level approaches the concept of habitat preservation just mentioned):

1. Species level
2. Population level
3. Community or ecosystem level

THE SPECIES LEVEL

Concern here may center at the local or geographic population of the species rather than at the species over its total range. For example, the southern populations of the bald eagle, which are endangered, may be of considerable importance in decision making, as opposed the northwest and Alaskan populations, which are abundant. The peregrine falcon (*Falco peregrinus tundrius*) from arctic and subarctic regions is rare or endangered over parts of its range, but the eastern U.S. population (*F. p. anatum*) is extinct. Strategies for preservation or restoration of the two falcon populations are basically different. The former faces reduction because of chemical pollutants along the migratory route or on its Latin American wintering grounds (White and Cade 1977). Preservation seemingly involves a land treatment practice change in those countries. In the case of the latter, which has already been extirpated from its range, the strategy being employed is the reintroduction of captive-bred stocks into its former range. To help design the rationale and process necessary to effect a recovery of population numbers, as with the falcons just mentioned, and to provide a financial basis to help accomplish that process, the concept of the recovery plan (Porter and Marshall 1977, Marshall 1978) was conceived.

Concern may be for the species on its breeding grounds because those breeding grounds may be limited or localized, rather than for the animal at other times of the year. For example, the northern fur seal (*Callorhinus ursinus*) breeds locally on the Pribilof Islands, but at other times of the year it can be widespread in the Pacific Ocean and Bering Sea. The short-tailed shearwater (*Puffinus tenuirostris*) is localized as a breeder in southeastern coastal Australia, but in the nonbreeding season it is very widespread and even common.

A now common strategy at the species level is captive breeding or propagation for later release into the wild. The recent book on endangered birds edited by Temple (1978) covers this strategy in great detail, along with numerous other species-oriented strategies. Zimmerman (1975) has also chronicled several of these strategies and refers to what he calls clinical ornithology, or the development and implementation of techniques for specific actions.

Genetic manipulation is a strategy not yet fully explored. The rare Edward's pheasant (*Lophura edwardsii*) is being crossed with the more common and closely related look-alike Swinhoe's pheasant (*Lophura swinhoii*). The F-1 offspring are then backcrossed with Edward's pheasant and so forth with successive backcrosses, each time diluting the amount of Swinhoe's genetic material. The design of this strategy is to genetically "rebuild" the Edward's pheasant. Wilson and Willis (1975) carry this concept further and suggest that certain strains of animals might be molded genetically to fit into communities where none now fit or where one has become extinct.

Genetic engineering (cloning, etc.) is also now a very real possibility for the saving of some animals by producing large numbers of them from a single individual. Such techniques, were they to become developed to the necessary extent, could save literally hundreds of dollars in the production of costly, hard-to-breed species such as the peregrine falcon. On the negative side, however, genetic diversity would become drastically reduced.

Foster parenting and cross-fostering are other species strategies that have proven successful with such birds as falcons and the whooping crane (*Grus americana*) (cf. Drewien and Bizeau 1978, Fyfe et al. 1978, and

Temple 1978a).

At this time, some of the strategies that can be devised frequently have only species-specific application. Beyond that, the real need is to design approaches and strategies that will have more general and widespread application, where several species may fit under the same program in an effort to reduce the financial burden. A list of some species, the cause for endangerment, and strategies projected to reduce their endangerment is given in Table 1.

THE POPULATION LEVEL

At this level we must first determine what the critical or effective breeding size of the population really is. Knowledge of that parameter may alter the approach used to help the population. It has been suggested that the Laysan duck (*Anas laysanensis*) was reduced to but one pair, and from there the population has rebounded to a self-sustaining wild population plus several score in captivity. The Mauritius kestrel (*Falco punctatus*) rebounded from 4 individuals in the wild in 1973 to 12 in 1976 after they adopted a new nesting habitat free from maurading monkeys (Temple 1978b). Populations reduced to such low levels may be subject to the incorporation of genetic weakness, as suggested by Bonnell and Selander (1974) in their study of the elephant seal (*Mirounga angustriostris*).

Populations that have not been reduced

TABLE 1. Examples of rare or endangered taxa showing known or probable major contributory causes of endangerment and possible or currently working strategies for preservation or trend reversal. There may be multiple causes or strategies, but only those that are seemingly the major contributors are given. This table is meant solely to provide examples of the array of strategies and is not intended to be complete.

Taxon	Cause of endangerment	Strategy for preservation
California Condor (*Gymnogyps californianus*)	Loss of habitat and food base, disturbance, perhaps pesticides	Habitat purchase for preserves, supplemental feeding, captive breeding
Puerto Rican Parrot (*Amazona vittata*)	Predation, over-exploitation, loss of habitat	Preserves, altered nesting conditions
Aye-Aye (*Daubentonia madagascariensis*)	Habitat loss	Habitat reserves
Malagasy lemurs (Lemuridae)	Habitat loss and persecution	Habitat reserves
Night Parrot (*Geopsittlacus occidentalis*)	Habitat loss	Habitat reserves
Ground Parrot (*Pezoporus wallicus*)	Habitat loss	Habitat reserves
Houston Toad (*Bufo houstonensis*)	Habitat loss	Habitat reserves
Western Swamp-turtle (*Pseudemydura umbrina*)	Habitat loss	Protected habitat reserves, captive breeding colonies
Noisy Scrub-bird (*Atrichohrnis clamosus*)	Habitat loss	Protected habitat reserves
Hawaiian Stilt (*Himantopus mexicanus knudsoni*)	Restricted habitat with habitat loss	Habitat acquisition and preservation
Socorro Isopod (*Exosphaeroma thermophilum*)	Restricted habitat with habitat loss	Maintenance of water levels, maintenance of artificial habitat, reestablishment into natural habitat
Masked bobwhite (*Colinus virginianus ridgwayi*)	Habitat loss or alteration	Reintroduction into habitat reserves
Black Robin (*Petroica traversi*)	Habitat loss or alteration	Reintroduction into habitat reserves

Red Wolf (*Canis rufus*)	Habitat alteration followed by hybridization	Secured habitat without related canids
Palila (*Psittirostra bailleui*)	Habitat loss and competition	Elimination of competitors from reserves
Hairy-nosed Wombat (*Lasiorhinus krefftii*)	Habitat loss and competition	Establishment of additional colonies in protected areas
Bridled Nail-tailed Wallaby (*Onychogalea fraenata*)	Habitat loss and introduced predators	Protected reserves
Pahrump Killifish (*Empetrichthys latos*)	Restricted habitat, habitat loss, and introduced competitors	Managed habitat reserves
Pupfish (*Cyprinodon* sp.)	Restricted habitat, habitat loss, and introduced competitors	Managed habitat reserves
Stock Island Tree Snail (*Orthalicus reses*)	Habitat loss or alteration because of commercial development	Protected reserves
Callippe Silverspot Butterfly (*Speyeria callippe*)	Habitat loss or alteration because of commercial development	Protected reserves
Cranes (Gruidae)	Winter habitat loss	Reserves, artificial feeding stations
Whooping Crane (*Grus americana*)	Habitat loss, over-exploitation	Manipulated nesting biology, cross-fostering young, captive rearing
Bermuda Petrel (*Pterodroma cahow*)	Introduced and other predators, over-exploitation	Habitat preservation, nest site modification
Giant Pied-billed Grebe (*Podilymbus gigas*)	Hunting, introduced predators, habitat loss	Habitat preservation
Utah Prairie Dog (*Cynomys parvideus*)	Over-exploitation, habitat loss	Relocation, habitat preservation, legal protection
Hawaiian Goose (*Branta sandvicensis*)	Habitat loss, over-exploitation, introduced predators	Reintroduction into habitat preserves; captive breeding
Kirtland Warbler (*Dendroica kirtlandi*)	Relict, limited habitat, habitat alteration, nest parasites	Manage reserves, reduce parasites
Sea turtles (Cheloniidae and Dermachelyidae)	Commercial and other over-exploitation, habitat loss	Legal protection, captive rearing reintroduction
Whales (Cetacea)	Over-exploitation	Legal protection
Black-footed Ferret (*Mustela nigripes*)	Loss of prey base, direct exploitation	Habitat and prey base preservation, reintroduction
Jaguar (*Panthera onca*)	Over-exploitation, persecution for pelts	Legal protection from hunting
Bald Ibis (*Geronticus eremita*)	Precise causes unknown, direct persecution?	Alteration and preservation of nesting substratum
Giant Otter (*Pteronura brasiliensis*)	Persecution for pelt	Legal protection from hunting
Ryuku Rabbit (*Pentalogus furnessi*)	Predators, overhunting	Maintenance of reserves, elimination of stray dogs
South American River Turtle (*Podocnemis expansa*)	Persecution for food	Legal protection
Golden Frog (*Atelopus varius zeteki*)	Collecting	Legal protection
Peregrine Falcon (*Falco peregrinus anatum*)	Chemical pollutants	Captive breeding and reintroduction
Arabian Oryx (*Oryx leucoryx*)	Overhunting	Captive breeding and reintroduction, preserves

below that effective size for self-maintenance, although there may be few individuals, can probably be maintained within large patches of habitat or natural reserves (Diamond 1975, Terborg 1974).

Unfortunately, natural reserves often end up being national parks and the like. When national parks are relegated to unused portions of land or are built around scenic attractions, they may fail to preserve animals in the manner needed. Pickett and Thompson (1978) have designed reserve concepts based on a "minimum dynamic area" or what they also call "patch dynamics" wherein reserves must be large enough to maintain internal recolonization sources (cf. Lovejoy's comments, this volume, on minimum critical size of ecosystems). Such a reserve would be in effect sort of a megazoo. These areas should have the following properties: (1) large, (2) circular, (3) undivided or, if divided, connected by corridors, and (4) close to one another. Figure 1 depicts a schematic drawing of such reserves and is based on Diamond (1976) and Wilson and Willis (1975). Notice that national parks or monuments seldom have these criteria. Hence, such reserves must be set aside specifically for the saving of certain populations or groups of species. In dealing with this approach in tropical rain forest invertebrates, Elton (1975) has concluded that these reserves must be very large indeed to insure success (self-sustaining populations) within these forests, because the organisms are at such low densities.

The Community or Ecosystem Level

The final level at which strategies can be aimed is the community or ecosystem level. This is probably the level at which deterioration that eventually leads to endangerment generally first starts. King (1978), for example, shows that 65.3 percent of the cases of the rare or endangered birds is caused by ecosystem (habitat) destruction.

It is at the ecosystem level that ecological engineering may be effective. Wilson and Willis (1975) discuss the orphan species, or those organisms on the brink of extinction in their native range but capable of being fitted, in the ecological sense, into certain alien communities. Such "fittings" have manipulative overtones characteristic of ecological engineering. An example of such a fitting through transplanting of a species, but not a true orphan species (*sensu stricto*) in the context of Wilson and Willis, comes to mind when thinking of the Norfolk Island parrot (*Cyanoramphus novaezelandiae cookii*). This population is unique to Norfolk Island, where some 40 or so remain (J. M. Forshaw, pers. comm.). A closely allied population did occur on Lord Howe Island, but was eliminated by persecution from early residents of the island (both islands are in the Tasman Sea between New Zealand and Australia). Here then, on Lord Howe, an appropriate habitat exists intact but there is no parrot to fill it. The problem of endangerment on Norfolk is the result of the introduction of another parrot, the crimson rosella (*Platycercus elegans*), an aggressive, competitive species that is displacing the Norfolk Island parrot. A seemingly workable strategy is to transplant the Norfolk birds to Lord Howe Island, where they are free from another competitive parrot and in a habitat similar to the one from which they were taken.

Spellerberg (1975) has worked with the three snakes and three lizards in Britain (essentially the entire British reptilian fauna), where they are being threatened by the loss of habitat to land development or by man-caused fires. By examining their behavior and ecological physiology, he concludes that the strategy best suited to the saving of these species is the reconstruction of islands of habitat into which the entire reptilian communities can be relocated.

Holt and Talbot (1978) and Wagner (1977) have described the value of ecosystem management rather than species management. Holt and Talbot suggest that when management is for single stocks or species it is often done so to the exclusion of a knowledge of:

1. Relationships within trophic levels
2. Relationships between trophic levels
3. Impact on symbiotic or commensal relationships
4. Changes in carrying capacity due to factors such as climate, pollution, or other human influences

Regardless of the level at which one wishes to approach a given strategy, much of what

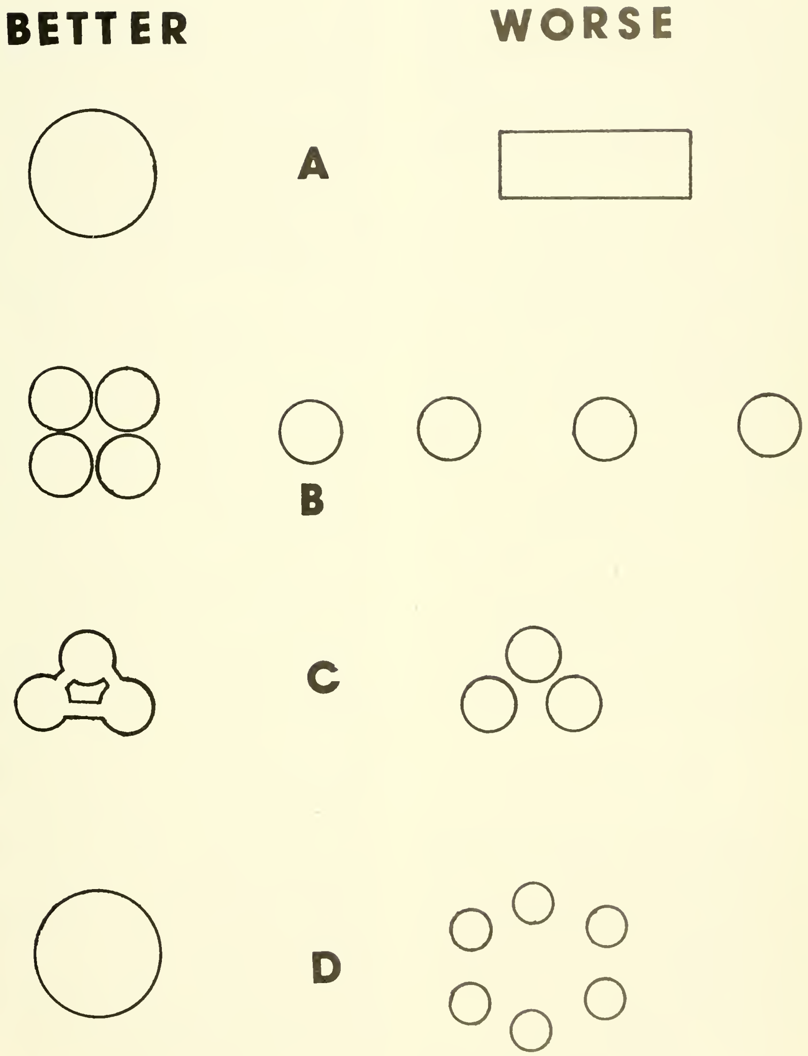

Fig. 1. The conceptual design of faunal reserves. These configurations are based on current theory of biogeography as relates to area of habitat, extinction, and recolonization rates. A: a circular reserve is better because of the peninsular effect of a long, narrow one. B: closely clumped reserves are better because of distance effect. C: reserves connected by corridors of habitat are better than disconnected ones. D: a continuous reserve is better than a fragmented one because of the effect of area. (These data are modified from Diamond 1976 and Wilson and Willis 1975).

is done will depend on whether the goal is to preserve or protect the animal or to restore it, or whether the treatment is aimed at the proximal or the ultimate cause of endangerment. Many of the federal or international acts and conventions are in reality strategies that function in providing a certain level of protection until a plan to aid the species in whatever way necessary can be enacted (Schreiner and Ruhr 1974, Schreiner and Senecal 1978).

With the higher vertebrates most of the endangered forms have biological characteristics of a K-selected rather than an R-selected species (Pianka 1970) and are, also, either plagued with reduced survivorship or reduced fecundity. These parameters were among those considered by Adamus and Clough (1978), Ramsay (1976), and Sparrowe and Wight (1975) in evaluating species or setting priorities for the inclusion of species into reserves or natural areas or for program management. The priorities were given to animals based on such species characteristics and properties as (1) suitability (mobility, area size needs, etc.) or (2) desirability (scarcity, endemicity, vulnerability, etc.). Ramsay (1976) has suggested that, regardless of whether the problem is approached through environment (eco-unit), preservation, or the maintenance of species diversity, a priority system at the species level, based on economic, biological, or cultural and aesthetic values can be developed.

Specific Strategies

Let me now cite a few specific examples where a given strategy has been employed or can be clearly viewed as the means to employ. The examples will apply to the species level because most of the knowledge is there and the problems at the population, community, or ecosystem level are just now being approached. These are also selected strategies with simple approaches.

Example 1.: Introduced predator or competition from domestic livestock as a major cause of endangerment.

The plains wanderer (*Pedionomus torquatus*), pig-footed bandicoot (*Chaeropus ecoudatus*), and grass owl (*Tyto longimembris*) in Australia; Aleutian Canada goose (*Branta canadensis leucopareia*) in North America; and the Galapagos tortoise (*Geochelone elephatopus*) are some examples of these. In the case of the Aleutian goose, the artic fox (*Alopex lagopus*) introduced onto the islands nearly brought about the goose's total demise by its predation (Springer et al. 1978). The foxes were eliminated from several islands and captive-bred geese (from the single wild-breeding population rediscovered in the early 1960s on Buldir Island, where about 500 pairs breed) were then transplanted back onto the islands where fox had been removed. The major obstacle now seems to be the geese being able to make a successful migration from their breeding grounds to their California wintering grounds and back to the Aleutians. The success of this plan remains yet to be achieved. It is of interest that during the decades between the 1930s and the 1970s the goose was shot on its wintering grounds, and yet the Buldir Island population appears to be at carrying capacity. Total protection may produce some interesting changes in the nonbreeding population structure, although all of this remains to be documented over the next decade or so.

The Galapagos tortoises on Hood Island were reduced to one male and 5 or 6 females by introduced rats (*Rattus* sp.) that ate young and feral goats (*Capra* sp.) that destroyed the tortoises vegetative food sources (Michael Harris, pers. comm., 1978). All the adults were taken into captivity and about 100 young tortoises were raised. Goats have now been removed from Hood Island (M. Harris, pers. comm.) and the tortoises' food supply appears to be coming back. Once the young tortoises reach about four years of age they are large enough to be released and rats will not depredate them. Because the tortoises do not breed until about 40–60 years of age, there will be time to work on the problem of eliminating the introduced rats. Apparently there have been no young tortoises raised this century on Duncan Island because of rat predation (M. Harris, pers. comm.).

In Australia there is a wingless, undescribed orthropteran called P-42 (Key, 1978) that survives in only six localized areas of lightly grazed pastures. There they are asso-

ciated with one of the native composite plants of the genus *Helichrysum*. This composite is eliminated by heavy livestock grazing. The apparent strategy is a simple one of controlling or eliminating grazing from these localities. If some of these localities are on Crown Lands, the task of controlling grazing will be made easier.

Most populations on islands (either habitat or geographic islands) can be protected by simply controlling the introduction of predators or by eliminating them from islands where they have previously been introduced. Many of the examples in Table 1 fall into this category.

Example 2.: Major habitat alterations or losses as a principal cause of endangerment.

A prime example in such a case can be seen in the bony-tail chub (*Gila elegans*), razor-back sucker (*Xyrauchen texanus*), and Colorado squawfish (*Ptychocheilus lucius*) in the Colorado River. The construction of dams or direct use of the water by man has caused at least two major classes of change, namely, (1) alterations of natural water cycles (dam, dewatering, stream flow changes, etc.) and (2) water quality changes (silt loads, temperature, pollution, etc.) (Seethaler 1978, Minckley 1973). The introduction of exotic fishes may also have helped to reduce these species to critical levels. Breeding cycles, correlated with such parameters as silt loads, stream bottom morphology, and temperature, have been reduced or eliminated and, although attempts at spawning by the chub and squawfish are observed, juveniles are infrequent or lacking. A nice correlary exists with the Macquarie perch (*Maequaria australasica*), trout cod (*Maccullochella mitchelli*), and Murray cod (*Maccullochella macquariensis*) of the Murray-Darling river system in Australia. These fish need high silt loads, flooding, and fluctuating river conditions, as are common with spring rains, to initiate spawning (Lake 1971). Dams and reservoirs have flattened out fluctuations and lowered silt loads. On one portion of the river there has been no flooding since 1939 because of dams (Roughley 1951). The fisheries industry and introduced European carp (*Cyprinus carpio*) have also had their impact on reducing these species. One solution to this problem in both North America and Australia is to introduce these species into streams with the necessary parameters where dams do not occur. Currently, of about 50 species of Australian fresh water fishes (most are endemic), about one-third are endangered or threatened, many because of man-caused changes in water conditions (Lake 1971).

The above examples tend to be very straightforward causes of endangerment, and in some cases the solution to alleviating the problems is rather simple. Most frequently, however, there are not single but multiple causes of endangerment. These have no easy or readily obvious workable strategies for solving the problem. The Higgins eye mussel (*Lampsilis higginsi*) of the Mississippi River system is an example wherein at least the following six factors have a measurable adverse impact:

1. Excessive commercial exploitation
2. Water quality degradation (industrial wastes, pesticide run off, etc.)
3. Increased siltation and turbidity
4. Dredging
5. The effective impact of exotic clams which dislodge the Higgins eye from attachment locations
6. Possible reduction of host fish species for larvae

As a final statement, perhaps the most important and critical strategy at this stage is to engage young, innovative minds in determining quickly and efficiently what the problems are, wed the multiple interests and groups into a common cause, decide what the priorities should be, and solve the specific problem at a minimum effective financial cost. Something as simple as convincing the Australian farmer that dead snags of the river red gum (*Eucalyptus camaldulensis*) do not take up significant space and that he should leave them in his field may be all that is needed. These trees contain many cavities and provide nesting places for a myriad of species. That one simple judgement, not to burn down the dead tree, may have far-reaching impact. Ramsay (1967) has rightly pointed out that our judgments must be preceded by as much forethought and rationality as possible because developing priorities for preser-

vation decisions favors an analysis of species from the viewpoint of human values. These values may indeed not be the critical ones for the integrity of a healthy ecosystem. Nonetheless, some value judgements (Myers 1976 and Holliday 1978) as to the worth of species and man's stewardship must be the first step in the long and never-ending process of maintaining a diverse ecosystem.

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RARE SPECIES AS EXAMPLES OF PLANT EVOLUTION

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ABSTRACT.— Rare species, including endangered ones, can be very valuable sources of information about evolutionary processes. They may be rare and valuable because: (1) they are evolutionary youngsters and could represent an entirely new evolutionary strategy of great scientific and practical value; (2) they are evolutionary relicts that have stored enormous amounts of genetic information of great worth; (3) they may represent endemic varieties that harbor a great deal of the genetic variability in the gene pool that would be of enormous value to a plant geneticist; the rarity of the plant is not necessarily correlated with the size of its gene pool; (4) they may represent unique ecological adaptations of great value to future generations. Studies of gene pools and the genetics of adaptation constitute a new and developing field of the future.

This morning I'm talking about a somewhat different topic than yesterday evening and one more in line with my usual interest because, as many of you know, I am primarily an evolutionist. The theme that I would like to develop is that rare species, including the endangered ones, can be very valuable sources of information about evolutionary processes. To illustrate that theme, I am going to give you examples of four alternative, but not mutually exclusive, theories that have been suggested for the reason that species are rare. One of the oldest, which was championed in the early part of the 20th century by J. C. Willis, was that the rare endemic species were youngsters. They appeared on the earth recently and haven't had time to spread. He wrote a whole book on the subject, which he called *Age and Area.* I first heard of that book from my systematics professor, M. L. Fernald, who was very much interested in rare species. He regarded them as senescent relics, and strongly opposed Willis's theory. However, Willis was partly correct. We have perhaps more direct evidence of this than for any other hypotheses. This is expected, because the origin of some new species would be recent enough that we would know when it appeared. A now classic example is that presented by the late Marion Ownbey, of Washington State University, with respect to the goatsbeard genus, *Tragopogon.*

Projected on the screen is a chart which Ownbey put in the *American Journal of Botany* in 1950. The three species which are listed all have the chromosome number $2n = 12$. They are well-known European plants introduced as weeds into North America. There are no species of *Tragopogon* in the Old World that have chromosome numbers higher than $2n = 12$ and $n = 6$. However, in the backyards and railroad yards around Pullman, Washington, Ownbey found two different entities having 24 chromosomes, twice the number of all the others in the genus. By a series of ingenious hybridizations and analyses of chromosomes, he established without doubt that one of them, described as a new species, *T. miscellus,* was derived from hybridizations between *T. dubius* and *T. pratensis.* Its chromosome number has been doubled either before or after the initial hybridization, giving us a stable intermediate, a principle long known to geneticists. A second species, *T. mirus,* has originated in the same way from a cross between *T. porrifolius* and *T. dubius.* Because *T. dubius* did not exist in western North America before about the 1890s, the age of these two species when he first found them was not more than a half century. They now are spreading. They are known in one or two places in Montana. There is another locality in Arizona. They are certainly not endangered. A hundred years from now, they may have become com-

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mon weeds.

There are other very young examples, not quite so young as these. Indirect evidence suggests that some species have arisen since the retreat of the glacial ice from northern North America and the drying up of the climate in places like California where the Pleistocene was a rainy or pluvial period.

One example is that of three species in the genus *Layia*, or "tidy tips," an annual plant of the composite family, or Asteraceae. The three species involved are *L. jonesii*, *L. munzii*, and *L. leucopappa*. They are very closely related, on the border line of becoming species. They can be hybridized easily and the hybrid is partly fertile. They are more distantly related to *L. fremontii* and *L. platyglossa*.

Their distributions are as follows: *Layia jonesii* occurs near the coast of south central California, not far from San Luis Obispo; *Layia munzii* is found in the small valleys of the inner south coast ranges; and *L. leucopappa*, in the central valley of California, on one or two hillsides not far from Bakersfield. They are closely related entities occupying neighboring areas in the same general region. The climate of this region was drastically changed in the Pleistocene. It seems likely that the splitting of these three populations from each other is post-Pleistocene, about six to eight thousand years ago.

Layia munzii is on the border line of being rare in a dry season, but is certainly not endangered. *Layia jonesii*, being on the coast, might be endangered. *Layia leucopappa*, in the highly cultivated central valley, definitely is endangered. A nature conservancy group, located in Bakersfield, is very much interested in it. It occurs on a large private range area, the manager of which says they are going to preserve it for us. This is a case of a young species which is on the rare and endangered list.

Another example of a similar nature is a species of larkspur. *Delphinium hesperium* is a common widespread species of the oak woodlands in the inner coast ranges of California. *Delphinium recurvatum* is found in the central valley and bottom lands and *Delphinium gypsophilum*, as the name implies, lives in gypsumlike soil on the hills bordering the valley. It occupies a habitat between the other two species. *Delphinium hesperium* and *D. recurvatum* have been crossed. The hybrid is partly fertile and looks like *D. gypsophilum*. The interesting thing is that when the F-1 hybrid is crossed with native *D. gypsophilum* it is found to be more compatible than the cross with either of its own parents. This is pretty good evidence that the native *D. gypsophilum* is derived from hybridization between the two other species. This again is a recent species. It is too common to be on the rare and endangered list, but it is certainly recent and uncommon relative to its ancestors.

An ancient species is the California Big Tree, *Sequoiadendron giganteum*. It is confined to certain groves in the Sierra Nevada in California, extending from Sequoia National Forest in the south in Tulare County into ever-smaller groves, to a very tiny one in the northernmost area in Placer County to the west of Lake Tahoe. It does not have a much-restricted gene pool. Horticulturists have found they can extract various modifications of it by simple inbreeding. Daniel Axelrod, with his brilliant studies of the paleobotany of western Nevada, has shown that California Big Tree was very abundant in Pliocene forests, six, seven, or eight million years ago in western Nevada when the Sierra Nevada didn't exist and the climate of Nevada, due to moist winds from the ocean, was still relatively mesic. Because of the Pleistocene changes in climate, it has become restricted in two ways: (1) the elimination of the stands to the east of the Sierra Nevada by aridity and (2) the reduction of the stands in California by the increasing length of the rainless dry summer. I say this because of research by the late Woodbridge Metcalf, extension forester at Berkeley. He showed that the big tree would seed itself only in a year when the dry season from May till October is shorter than usual. If it gets a few of these short dry seasons between seed germination and the time when the trees are 8–10 years old, then it competes with sugar pine, white fir, and other forest species. If young trees are exposed to a succession of normal dry summers, they cannot compete with the seedlings of the other species. This, then, is an example of an ancient species.

There are some others. One of the inter-

esting things that Professor Jack Major and I worked out some years ago is that the concentration of rare relictual species, which were more common in the past, is bipolar in California. It represents two elements, first a northwestern element which is related to the Pacific Northwest and Asia. The species involved are mainly trees or shrubs related to holarctic members of the same genera. Examples are the Weeping Spruce (*Picea breweriana*), which is narrowly restricted to this area. The Sadler Oak (*Quercus sadleriana*) is related to the Chestnut Oaks of the eastern United States, and is restricted to the Siskiyou Mountain area. The Port Orford Cypress (*Chamaecyparis lawsoniana*) is in this area. It contains several endemic species of mesic genera like *Vancouveria* and some genera of the saxifrage family.

In the southern area occur rare, endemic species like *Hesperocallis* of the Lily family, the jojoba shrub, *Simmondsia*, not particularly rare but certainly relictual.

By contrast, central California contains endemic species, which seem to be new like those of *Arctostaphylos* or *Manzanita*, already discussed, and other annuals. Because central California has received the greatest disturbance in relatively recent times, one can get some idea of whether a species is relictual or not, both by its taxonomic affinities and by the geographic areas in which it grows.

An example of an herbaceous species from the northern relictual area is *Darlingtonia californica*. It does not have official preservation that I know of in California. It should, because it is an attractive species, an insect-digesting pitcher plant. Every high school biology teacher wants one in the classroom, and people also like them in their homes. There is danger to them from vandalism. I sometimes blush when I go up the Oregon Coast Highway and see that Oregon has a preserved area of *Darlingtonia* labeled as such, while California doesn't.

The next group of rare and endangered species are of an entirely different nature. Here, I want to state publicly that one of my articles written in 1942, and often quoted, apparently is not correct. In 1942, I made the speculation that rare and restricted species would usually be so because of restricted genetic diversity. At that time I was influenced by the work of Sewall Wright on inbreeding and its ramifications, which was very popular at that time. Now we have data on restricted species like *Clarkia franciscana*, which grows in only a single hillside in the city of San Francisco and which, as my colleague Leslie Gottlieb has shown, has as much biochemical variability in it in terms of enzyme alleles as *Clarkia rubicunda*, which is much more widespread throughout the San Francisco Peninsula. I now reduce the category of species that are rare because of restricted gene pool to a rather small one consisting of species that have not only become inbred because of small population size, but, in addition, because of the shift from cross-fertilization to self-fertilization or predominant fertilization. Again, Leslie Gottlieb has shown with his work on enzyme variability that in eastern Oregon there is a widespread species of the composite genus *Stephanomeria* (*Stephanomeria coronaria*), which has an enormous amount of genetic variability, but right next to it there is a very restricted species along Malheur Lake in eastern Oregon, *Stephanomeria malheurensis*, which has very little variability. One difference between the species is that *S. coronaria* is largely outcrossed and *S. malheurensis* is almost completely inbred. The inbreeding as much as the restriction in size of the population and habitat was responsible for the reduction in size of the gene pool. The same situation exists in some species of animals like the burrowing rodents of the Middle East, studied by several Israeli zoologists, and certain fishes in Mexican caves which have very restricted gene pools. One that is rather widespread, the southern alligator, apparently has extremely low variability in its gene pool. The whole hypothesis that there is a strong correlation between rarities and endangeredness and the size of the gene pool must be greatly modified, if not entirely rejected. In my own thinking, I am substituting the concept of ecological traps. Plant species may be hemmed in by environments that are so different from the ones in which they grow that they do not have the genetic potential to colonize those habitats. Sometimes the "traps" are quite clearly defined so that I call them ecological islands. Usually the soil

is so different on the islands, relative to that of the surrounding islands, that the plants are as if they were on an oceanic island surrounded by a sea of unfavorable soil conditions. Such an island is Pine Hill, 25 miles east of Sacramento. It consists of basic intrusives, a very distinctive type of rock, surrounded by the various metamorphic rocks commonly found in the Sierra Nevada foothills. Interestingly enough, this particular island is believed to have once been an oceanic island. Dr. Eldredge Moore of our geology department at Davis, in association with the new theory of Plate Tectonics, points out that basic intrusives are associated with the roots of volcanos. The situation could be explained if the rocks now exposed at Pine Hill were the roots of an ancient submarine volcano that arose in the Pacific Ocean to the west of what then was the seashore, but is now the eastern edge of the central valley. Because of crustal movements, this ancient island jammed itself against the older rocks.

A striking endemic on Pine Hill is *Femontodendron californicum* ssp. *decumbens*, a prostrate shrub that bears highly distinctive copper-colored flowers.

Another ecological island is in the area by Monterey and Pacific Grove. There are two species of rare endemic cypresses of the area. Neither of them is in danger now, because both are preserved. One is the well-known Monterey cypress (*Cupressus macrocarpa*), found only on the granite ledges near the shore. The other is the Gowen cypress, found only in the hard pan of the raised beach, in the interior of the peninsula.

Monterey pine is confined to the Monterey ecological island plus two others in California, one 50 miles north, the other 120 miles south. There is evidence that it is not restricted in its colonizing ability, if it has the right conditions, so that it could get out of its ecological trap. This is evident from what the Monterey pine has done in the southern hemisphere, in Chile, New Zealand, and Australia. In all three regions, extensive forests of this species have been planted that in many places look quite natural. Some trees are far taller than those in California, reaching heights of 100 to 150 feet.

Most interesting of all, in the vicinity of Canberra, Australia, I have seen Monterey pine seedlings invading a forest of native *Eucalyptus*.

A well-known ecological island exists in the Sierra foothills of California, near the town of Ione. It is based on a hard pan soil which is of Eocene age, about 40 million years old. It was a sea-beach terrace facing the Pacific Ocean, which at that time covered all of the present central valley. It is dominated in many areas by an olive-colored shrub, *Arctostaphylos myrtifolia*, the Ione manzanita. There is a margin of the common gray manzanita, *Arctostaphylos viscida*, and interior live oak, but most of the area surrounding it is grassland consisting of introduced annual grasses and scattered blue oaks and digger pines that are the normal dominant vegetation of the area. The plants that are rare and endangered are held in check by the very special ecological conditions that prevail here. There is really an island within an island because a buckwheat, *Eriogonum apricum*, which is confined to the Ione manzanita island, grows only in the few most barren parts of it.

The gene pool of *E. apricum* is most interesting. There are three patches of it. The maximum distance from one to another is about 10 miles and there is one about halfway in between. Rod Myatt of UC Davis did a master's study on morphological variability and found that the different patches can be distinguished morphologically. They are races. There is not only a lot of variation within each of these patches, but distinctive differences between patches. In other words, it appears as if the Ione manzanita within its area of 10 miles has as much morphological variability as does another buckwheat, *Eriogonum nudum*, within an area of equal size, 10 miles in diameter in the Sierra foothills. The difference is that *Eriogonum nudum*, one of the most common buckwheats in California, has a multitude of races that are adapted to all sorts of climatic conditions over this extensive area. Another fact is that *E. nudum* is a much bigger species and its seeds are much bigger. Its seedlings are probably much more competitive so that it could colonize new areas more easily than could *Eriogonum apricum*. Perhaps *E. apricum* is a relic of the days when annuals, even native annuals, were much fewer than they are now.

It may have colonized the barren places that no other perennials could live in, when there wasn't so much annual competition. That's pure speculation. This again emphasizes the ecological entrapment which I believe is the basis for understanding the distribution of most of our rare and endangered species, independent of age and independent of quantitative sizes of gene pools.

The final example is similar. It is Convict Canyon in the eastern Sierra Nevadas. It is distinctive, because while most of the Sierra is either granitic or ancient acidic crystalline volcanics of Mesozoic age or earlier, Convict Canyon has a vein of limestone running through it. It is the only sizable part of the Sierra Nevada that has limestone in association with alpine or subalpine conditions.

Mount Baldwin, 12,000 feet high, supports a rare rock cress, *Draba nivalis,* and is the only locality in the Sierra Nevada. The nearest to it, as far as I know, are the Ruby Mountains in eastern Nevada.

One of the most remarkable plants, however, in this area, is a willow which is related to a Rocky Mountain species. *Salix brachyocarpa.* Another species is a relative of the sedges, perhaps ancestral to the genus *carex Kobresia myosuroides* and an extremely localized dwarf bullrush, *Scirpus rollandii,* sometimes put in the species *Scirpus pumilus,* which has been the subject of interest for arctic alpine botanists for many years. The two discoverers of these species were Jack Major and Sam Bamberg.

Now, why do these rare plants grow here? It isn't because they are lime-loving calcophiles. The *Kobresia* grows on Mount Evans in Colorado which is acidic granite. Certainly *Scirpus rollandii* is to a certain extent a calceophile, but it doesn't seem as though the limestone is the basic reason. The other factor is this—limestone is porous. Because it holds water, on a steep slope like the one which supports the rare plants, water oozes out from the ground throughout the summer. Remember that the Sierra Nevada, in contrast to the Rocky Mountains or the Wasatch Range, has very few summer storms. They exist, but they're small and most of them hardly wet the ground. Much of the sierran area in the well-drained slopes becomes very dry in the summer, and the mesic plants have to grow where they get heavy snowfall during the winter. The rare plants, however, grow on a bench area that gets relatively less snow during the winter which is constantly coming out of the limestone formation. This, I believe is responsible for the unusual nature of the environment.

My final remark has become obvious from what I've had to say. Ecological genetics is a relatively new field. The combination between studies of gene pools and the genetics of adaptation, I predict, is a field which is just beginning to emerge and will be explosive in the next half century. Young scientists who are interested in native environments and wish to study them in depth from an analytical point of view will have an exciting career of discovery ahead of them.

THE MEANING OF "RARE" AND "ENDANGERED" IN THE EVOLUTION OF WESTERN SHRUBS

Howard C. Stutz[1]

Abstract.— In the evolutionary process, species continually come and go. Consequently, all species on earth today were, at one time, "rare and endangered" while in their infancy, and most will become "rare and endangered" once more as they are replaced. Therefore, decisions relative to protecting rare and endangered species are largely meaningless if based on numbers alone. They must include information about their biology and evolutionary history. Lists of endangered forms currently being prepared apparently include only those which are (1) scarce (rare and of restricted distribution), (2) named, and (3) sponsored. Their biological, economic, and academic values may be more important, but apparently are not often considered. As abundantly illustrated in western shrubs, genetically rich genotypes are sometimes maintained by only a few individuals, whereas uniform, and therefore rare, genotypes may in some circumstances, be represented by many individuals in uniform environments. Wise management decisions cannot, therefore, come from numbers alone.

Interpretations of the origin of species indicate that all species now on earth were at one time rare and endangered. Whether they arose slowly by accumulating mutations that permitted divergence from parental forms, explosively as polyploid derivatives, or as recombinants from interspecific hybrids, they all had humble, precarious beginnings. Furthermore, they represent but a tiny fraction of all that might-have-been. Many are undoubtedly inferior to former contemporaneous taxa which, although superior genetically, were lost by fortuitous accidents during their infancy.

As species come and go in response to the challenge of an ever-changing world, some are rare simply because they are new, others are rare because they are being replaced by more adaptive competitors. All species are endangered in the sense that they are successful only as long as the environment in which they are superior endures, or until other modified, improved competitors replace them.

Intelligent intervention in this efficient, sifting, ever-improving drama in the guise of protecting threatened species, requires therefore understanding the evolutionary dynamics which define them. Because artificial protection of any species may concomittantly impose intensified selection against all other associated species, utmost care and caution is essential in management decisions designed to deliberately favor specified taxa. Some species, represented by many individuals but which are genetically uniform, in certain circumstances may be far more in danger of extinction than "rare" species which are genetically diversified.

Protective measures aimed at preserving one particular taxon may be detrimental to the entire ecosystem. However, rare forms which are of high intrinsic value because of their potential for improving an ecosystem, or for providing a fountain of genetic variables from which other new improvements can arise, or for providing economic or aesthetic benefits for mankind may deserve deference and intense protection.

Decisions regarding management of ecosystems designed to preserve "rare" and "endangered" species are therefore always precarious and are essentially indefensible unless founded on intimate knowledge of the genetics and genealogy of affected species.

As rosters of rare and endangered species begin to emerge, it is important that definable criteria be used for deciding whether or not a species is to make the roster. Apparently, to date, only three ingredients are required:

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(a) Scarcity (rare and of restricted distribution)
(b) A name
(c) A sponsor

Apparently it has had nothing at all to do with value. Also, (b) is not independent of (a) nor is (c) independent of (b). If scarce, a species may not have a name; if unnamed, it will almost never have a sponsor.

Actually, however, because favoring one species may concomitantly disfavor another, decisions cannot really evade value judgements. In my opinion, they *should* not. I would recommend that they deliberately include at least the following:

(a) **Aesthetic values**, including beauty, uniqueness, antiquity, etc.
(b) **Biological values**, particularly in relationship to genetic potential and contributions to the ecosystem.
(c) **Economic values** which would include their contribution to wildlife, to range use, to industry, to recreation, etc.
(d) **Academic values** including contributions to the interpretations of evolutionary history, geological events, climatological changes, and ecological succession.

Illustrations of rare forms which are being replaced and may, therefore, not invite human intervention for their protection, as well as forms which are "brand-new," exciting, promising, arrivals and may, therefore, profitably be enhanced, are abundant in western North America. Recent major geological and climatological changes have provided a multitude of new habitats in which newly formed species have been and still are being favored. Concomitantly, similar other populations have become reduced or extinguished as their required niche disappeared. Examples may be found in nearly all groups of plants and animals; the following are illustrative:

1. The Rose Family

In the rose family, *Cercocarpus*, *Purshia*, and *Cowania* have all shown explosive response to recent habitat changes. However, management decisions concerning the accompanying rare and endangered forms of these genera will of necessity vary, simply because each has a distinctive evolutionary meaning.

In *Cercocarpus*, three principal species are known in the Great Basin: *C. montanus*, *C. ledifolius*, and *C. intricatus*. Natural hybrids are common between *C. ledifolius* and each of the other species, but are rare between *C. montanus* and *C. intricatus*, even when they are sympatric (Plummer et al. 1957, Pyrah 1964). *Cercocarpus intricatus* is the most xeric of the three, often growing on steep, exposed limestone cliffs, but it is found only in Utah and the immediate borders of neighboring states. In areas where *C. intricatus* and *C. ledifolius* grow together, there is often such a continuum of intermediates that individual plants are difficult to define. For these reasons, it appears that *C. intricatus* has been recently derived from *C. ledifolius*, having acquired adaptive attributes by rapid genetic assimilation of drought-resistant phenotypes which were, and still are, latent in *C. ledifolius*. Similar evidence, although less straightforward, suggests that *C. montanus* may also have been derived from *C. ledifolius* by selection of types that were more competitive in the more densely vegetated mountain brush zone. The requirement for broader leaves, an apparent prerequisite for competition with *Quercus gambellii*, *Amelanchier alnifolia*, and *Prunus melanocarpa*, was apparently possible only if these broad leaves also became deciduous to escape the long winter drought of frozen soil.

If these interpretations of the recent and continuing evolution of *Cercocarpus* are valid, what might our decisions be, relative to the component rare and endangered forms? *Cercocarpus intricatus*, although recently derived and somewhat rare, is currently not endangered and probably needs little, if any, artificial protection. Its habitat is not often used by man nor by domesticated animals. Very little of the current impact of human civilization appears to be in any way threatening this species.

Hybrids and hybrid derivatives, however, are a different story. Not only are they very rare but they are also very important reservoirs of potential diversity and, in many cases, severely threatened. They are of value as demonstrations of biological evolution, as fountains of genetic combinations from which both *C. montanus* and *C. intricatus* might be enriched and from which even oth-

er species might arise, and as beautiful, rare specimens, with simple intrinsic aesthetic value. Although these populations may not represent species, they are important and in many instances deserve deliberate protection. However, because they are unnamed and, perhaps, even unnamable, because the individual plants are the unique rare entities, they may never make the roster.

Purshia and *Cowania*, two other genera of the rose family, are also rapidly evolving and have recently produced several new adaptive products (Stutz and Thomas 1964). While some of the new forms may have come from new mutations, almost all appear to have come as adaptive segregation products from intergeneric hybrids between them.

Purshia tridentata is distributed from southern Utah northward into Canada. *Cowania stansburyana* grows from northern Utah southward into Old Mexico. Consequently, almost the entire state of Utah is an overlap zone in the distribution of these species. In many places in Utah, where these two species come together, hybrids and hybrid derivatives are common. So commonplace is such hybridization there appear to be no populations of *Purshia tridentata* in all of Utah which do not contain introgressants from *Cowania* (Stutz and Thomas 1964). Many, perhaps most, are one of a kind. They apparently continually come and go with few if any ever being superior to their progenitors.

Here then is an example of species in which rare and endangered forms are rampant. But, as interesting as they are or as potentially valuable as they may be, attempts to protect them all would be absurd. Selected forms, or even selected individuals, may be locally desirable, but it would be impossible to preserve every noble segregant. The *Cowania* × *Purshia* F_1 hybrid and the segregating hybrid swarm northeast of Provo, described in detail by Stutz and Thomas (1964), might have been profitably spared but, because they have both already been completely obliterated by a recent housing development, that is now impossible. Protection of similar known F_1 hybrids and hybrid segregants is probably unwarranted. However, specific products that show unique adaptive promise may be profitably protected.

Near Clarkston, Cache County, Utah, a distinctive population derived from *Cowania* × *Purshia* parentage is on the verge of being exterminated by overgrazing. Although considerable segregation is still evident, many of the plants appear to be stabilizing around a unique combination of characteristics which are apparently adaptive in this area. The fruits, leaves, and habit are all intermediate between their putative parents. Because it is unlikely that this small population will survive long under present grazing pressures, adjustments in management of this area would seem highly desirable. However, it is unnamed and unnamable and will probably not make the roster even with me as its sponsor.

Other adaptive products from this parentage include a species of recent origin, *Purshia glandulosa* Curran, and a series of populations of *Purshia tridentata* throughout Idaho, Oregon, and Montana that have been enriched with *Cowania* genes by introgressive hybridization. Because the introgressed populations are being differentially favored by current grazing practices, they apparently require no deliberate protection. Sheep apparently prefer *Purshia tridentata* plants that contain no *Cowania* genes, so introgressed populations are becoming increasingly abundant. These "rare" forms are therefore not at all endangered and may eventually prove to be very abundant and perhaps even detrimental as range forage. In this case, the *rare* does not at all equate with *endangered*. Already it is becoming difficult to find "pure" nonintrogressed populations of *P. tridentata*. In time, they may indeed become the rare and endangered representatives.

Each population of *P. glandulosa* is also somewhat genetically unique. The particular combination of *Cowania* and *Purshia* genes that identifies the adaptive features of *P. glandulosa* is common to all populations, but other characteristics, under less severe selection, apparently segregate somewhat randomly. Consequently, plants in every population are similar with respect to the unique features which characterize them as *P. glandulosa*, but they differ considerably in other segregating attributes. Already *P. glandulosa* as a taxon is sufficiently well established that it is far from being rare or en-

dangered. Although individual variants may be "rare," they appear to be of little consequence in the evolutionary drama that is producing *P. glandulosa* as a newly derived species. Consequently, there appears to be little wisdom in deliberately preserving them even though they meet the rare and endangered criteria.

2. THE OAKS

Much of the variation in *Quercus gambelii* in northern Utah appears to be the result of introgression from *Q. turbinella*. Although in Utah these species are currently sympatric in only a limited area in the southern part of the state, hybrids are common along the Wasatch Front 200 miles to the north (Cottam et al. 1959). According to those authors, the hybrids were apparently left behind during the altithermal postglacial period when, because of milder climates, *Q. turbinella* was able to grow that far north. Although most of the intermediate forms are much alike and may be mostly F_1 hybrids, some segregation is apparent. Both "F_1 hybrids" and segregants are severely restricted to a narrow temperature-inversion belt at about 5,400 feet elevation where temperatures are normally higher than either above or below (Cottam 1959).

These rare hybrid specimens are of high aesthetic value and apparently also of high biological significance. If, as appears likely, much of the expressed variation in *Q. gambelii* is due to introgression from *Q. turbinella* via these hybrids, they have already made great biological contributions and promise to continue to do so as long as we permit them to remain.

However, many of these valuable specimens have already been destroyed and most of those that remain are threatened with extinction. One very unusual hybrid derivative near the mouth of Immigration Canyon, east of Salt Lake City, Utah, has recently been replaced by a house. This particular plant differed from both parents and all other segregants in having oval leaves with serrate margins. The leaves resembled superficially those of chokecherry (*Prunus melanocarpa*). It was a magnificent specimen with a speed of about 40 feet. It should have been preserved. If anything can be done to save the others, they will have longlasting significance biologically, aesthetically, and economically. But these unusual plants (*Q.* × *pauciloba*) may never make the roster.

3. THE SALTBUSHES

Many of the new habitats which have recently become available in North America are still completely unoccupied. Species have not yet evolved that can accommodate the numerous steep mud hills, salt flats, and alkali playas that characterize much of the western deserts. The plants at the borders of these sterile islands, and therefore closest to invading them, are almost all members of the family *Chenopodiacea*: *Salicornia*, *Allenrolfia*, *Sueda*, *Sarcobatus*, *Salsola*, *Hologeton*, *Grayia*, and *Atriplex*. Most of these genera are represented by only a few species and are therefore probably there because of characteristics acquired elsewhere that made them preadapted to these harsh sites. The principal exception is *Atriplex*. This genus is represented by numerous species and varieties, many of which appear to be of very recent origin. In some cases new successful forms appear to be no more than a few years old.

Every known evolutionary force appears to be operative in *Atriplex* at an accelerated rate (Stutz 1978). Species appear to be arising from new mutations, from introgressive hybridization, as new hybrid segregants from interspecific hybrids, as autopolyploids, and as allopolyploids. Rare and endangered forms are therefore abundant. Some are of obvious high value; many others are undoubtedly important.

One of the most successful species of *Atriplex* to invade western North America is *A. canescens* (fourwing saltbush). It has the widest distribution of all native perennial species, growing from central Mexico to Canada and from the Dakotas to the Pacific Coast. With such a wide distribution, it is probably not surprising that it is a highly variable species. Some of the variation is due to phenotypic plasticity, but most of it appears to be genetic.

Four different chrosome levels in *Atriplex canescens* are known: diploids, tetraploids, hexaploids, and twelve-ploids. Rare and endangered forms are found in each.

A. *The diploids* ($2n = 18$)

Individual diploid plants have been found

sporadically in several polyploid populations and hence are probably derived by polyhaploidy. They are certainly rare, and certainly endangered. But should they be protected? Probably not. None appears to have any capacity for increasing (partly because, being rare in a polyploid population, they can leave only sterile offspring). With more knowledge, some of them might be recognized as potentially valuable entities and might therefore warrant careful propagation and ultimately increase for some specific use. For the most part, however, we might expect these to be continually produced and continually discarded as novel but nonadaptive variants. Being rare and endangered in this case is probably insufficient license to receive any special protection.

Three distinctive diploid varieties are known, however, which are highly successful in specific habitats and are therefore very valuable. At least one of them is sufficiently rare to be considered endangered. All are probably relics derived from ancestral diploids rather than polyhaploids derived from polyploids.

The most abundant of these diploids, and probably the most ancient, is a form which is common in southern Arizona and also reported from southwestern New Mexico by Max Dunford (oral comm.). It appears to be the most drought resistant of all forms of *A. canescens*, growing sympatrically with creosote bush (*Larrea tridentata*) and mesquite (*Prosopis glandulosa*).

The other two diploids are narrowly endemic. One (*A. garrettii*) grows only in loose sandstone-talus along the Colorado River and at the mouths of its tributaries from 10 miles northeast of Moab, Utah, to Lake Powell. Many populations of this species disappeared with the impounding of water in Lake Powell.

Atriplex garrettii is a very fragile species and would probably be facing extinction were it not for the protection afforded by its inaccessibility in the steep canyons and narrow gorges along the stretch of the river where it grows.

The third diploid form is restricted to the Little Sahara sand dunes in central Utah. It is strikingly different from other *A. canescens* in its gigas habitat. Its growth rate is nearly twice that of the tetraploid forms that grow nearby (Stutz and Melby 1968). This rare form is becoming increasingly threatened. The sand dune retreat has apparently preserved it to date by excluding herbivores that have difficulty in walking on the dunes. Recent development of recreational facilities on the dunes by the BLM as a resort for dune buggy enthusiasts may spell its doom. Many plants are damaged directly by dune buggies; others are destroyed by people. Because this is almost the only woody plant available in this area, it is sometimes used as fuel. It is also highly palatable to livestock and has been harvested to feed horses. Other uses include mattresses for sleeping bags and makeshift windshelters. The handsome fruiting stalks are often gathered for home decoration. During the annual spring dune buggy racing events, thousands of people swarm over these dunes. Even the games they play take a toll.

Although requests have been made to protect this fragile population by restricting vehicle use to a small area, it is apparently going to be difficult to accomplish. This is a rare and endangered form which, although identified by a very vocal sponsor, has still failed to make the roster.

B. *The tetraploids*

Although collectively the tetraploids are abundant and widespread, numerous localized small populations are genetically unique. Many of these are obviously of significant biological value. Several deserve and need protection; others appear capable of holding their own.

Although some of the variation between tetraploid forms may reflect separate polyploid origins, most variations occur as products of interspecific hybridization. The following three examples are among the most common.

(1) *Atriplex canescens* × *confertifolia*.

Hybrids between these very different species have been previously reported by Plummer et al. (1957), Plummer and Drobnick (1966), and Hanson (1969).

The first one I found was in Elko County, Nevada, 10 miles west of Wendover. It was in an area which later became the median between the lanes of a freeway and was

therefore destroyed. From seeds harvested from it, however, 17 seedlings were obtained which are now growing in the BYU nursery. All of these plants appear very much alike in habit and leaf characteristics but are distinctively different from either parent and from all other species of *Atriplex*. Differences in fruit characteristic are apparently due to only a few genes which permit clear segregation in this small population. Other characteristics, such as habit, spininess, and leaf characters, do not conspicuously segregate, suggesting a more complex genetic control. Surprisingly, the males show regular meiosis, which implies that most of the differences acquired by these two very distinct species have come from gene mutations unaccompanied by gross chromosomal aberrations.

A large number of hybrids from this parentage have now been collected and progeny from them assembled in a common garden. From these, it appears that at least some of the natural variation present in both parental species has come from introgression from these hybrids. Near Honey Lake, California, a small population of *A. canescens* is obviously heavily introgressed with *A. confertifolia* genes. Near Garrison, Utah, a population of *A. confertifolia* appears to have received genes from *A. canescens.*

Should these hybrids and introgressed populations be included on the rare and endangered roster? Individually, they appear to be fully qualified. They are highly important as sources for new adaptive combinations. Some possibly might represent the beginnings of valuable species if they are spared. Will they need names to make the preferred list?

(2) *Atriplex canescens* × *A. cuneata.*

Although *A. canescens* is a large woody plant and *A. cuneata* is a low-statured herbaceous perennial, hybrids between them are common. They have been reported by Plummer et al. (1957), Plummer and Drobnick (1966), and Hanson (1969). Stavast (unpubl. no.) reported an extensive population of hybrid segregants west of Hanksville, Sevier County, Utah.

From natural hybrids, segregating seedlings have been grown to maturity in the BYU nursery. While most of them are more like *A. canescens* than like *A. cuneata* in habit and fruit characteristics, *cuneata* influence is unmistakable.

From observations of these garden-grown segregants, it has since been possible to identify several distinct introgressed populations in nature. One particularly striking form is becoming established near Ferron, Emery County, Utah, as a low-statured form, with small fruits and a capacity for growing with and favorably competing with, *Ceratoides lanata* and *Xanthocephalum sarothrae*, which neither parent can do. It now occupies only about 40 acres so is still rare and, of course, endangered. It may be the beginning of a very valuable addition to our rangelands if we can preserve it.

Other novel adaptive combinations from this same parentage are likely also forthcoming if the source is protected.

(3) *Atriplex canescens* × *A. gardneri*

Many years ago A. Nelson reported hybrids between *A. canescens* and *A. gardneri* and named them *A. aptera* (Nelson 1904). Such hybrids are still common west of Laramie, Wyoming, and elsewhere where these two species meet. They appear to have given rise to a series of very successful derivatives which now occupy the banks of most of the tributaries of the Missouri River in Montana, southern Alberta, southern Saskatchewan, North and South Dakota, and northwestern Nebraska. It was a specimen of this form which was collected by Lewis and Clarke in 1804 north of Chamberlain, South Dakota, and to which the name *A. canescens* was assigned. In most places it is low growing and shows vigorous root-sprouting, but some are quite woody. Some have broad wings on the fruiting bracts; some show only small traces of wings. Apparently segregation is still going on as unique combinations find habitats in which they are competitive.

Collectively these hybrid products are not at all rare or endangered, but local unique populations certainly are. Should they receive protection?

Several other interspecific hybrids involving tetraploid *A. canescens* from which segregating progeny are sometimes abundant and stabilized, sometimes rare and variable, have been found in western North America. Some have already yielded new adaptive in-

cipient species; others may yet do so from the rich common gene pool. Some of them will obviously require protection if they are to become established. Others already appear to be sufficiently established to be able to continue even with human assaults.

C. *The hexaploids*

Within many tetraploid populations of *A. canescens*, occasional hexaploid plants have been found. They are apparently continuously and sporadically produced from unreduced gametes. For the most part, they have not become established as separate adaptive derivatives. This is probably due primarily to the high improbability of two such hexaploid plants being produced simultaneously in sufficiently close proximity to each other to interbreed, and also, even if they did, it would be unusual for their offspring to be an improvement over the parental forms.

Even so, a few exceptional, small, localized hexaploid populations have been found in isolated pockets. In the White Sands National Monument, New Mexico, some very promising hexaploids have become established in localized colonies fairly close to the more abundant tetraploid form. In the BYU nursery, they show a shorter, more compact habit than the tetraploids and may have attributes which would be superior in particular range conditions. Because they are still few in number and sporadic in distribution, they could profitably use protection, but under current policy they appear to have little chance of receiving it though their existence under circumstances that severely hinder their establishment suggests they may have great potential for success once they get started.

The ephemeral hexaploids that appear as single plants in tetraploid populations, although rare and of course endangered, probably do not merit legislated protection, simply because they cannot demonstrate particular values until removed from their tetraploid neighbors and manipulated by plant breeders. Their potential may be high, but protecting them in their ephemeral infancy is probably not warranted, although they apparently meet all current prerequisites except for having designated names.

In contrast to rare, ephemeral, and localized small pockets of autohexapaloids, there are several allohexaploids that appear to hold great promise as new additions to the desert ranges. One of these is already abundant in the north-south-oriented valleys of Nevada. It appears to have been derived from the parentage 4N *A. canescens* × 2N *A. falcata*. Apparently doubling of the chromosomes in the triploid F_1 hybrid gave rise to a remarkably well-adapted new taxon. It is a short-statured form that often flowers during its first year of growth. Because there are marked differences between different populations, they have apparently arisen repeatedly at different places. Although, collectively, this hexaploid is well established, successful, and apparently capable of withstanding intensified grazing pressures, some of the individual component populations are genetically distinct and apparently sufficiently rare to be endangered. Should we attempt to protect these new arrivals during their fragile infancy, or shall we settle for the already acquired forms which are performing at least satisfactorily?

Another hexaploid fourwing derivative that appears to offer unique and exciting promise as a new adaptive taxon, has apparently come from the parentage 4N *A. canescens* × 6N *A. tridentata*. This interesting form occupies only about 80 acres east of Grantsville, Tooele County, Utah. It is upright and woody like typical nearby tetraploid *A. canescens* plants, but it has soft-textured furfuraceous leaves and late-maturing flowers and fruits like *A. tridentata*. It also grows on heavy clay soils as does *A. tridentata*.

This small population appears to be remarkably adapted to this valley and is apparently spreading. Currently almost entirely within a military reserve, it is already receiving needed protection during its infancy. However, if that protection were removed, the entire population could very quickly be lost. Indeed, were it not for the presence of the reserve, it may have never survived beyond its birth.

A hexaploid *A. tridentata*-like derivative from this same parentage has apparently come into existence only during the past decade. It is still confined to the roadsides along a 30-mile stretch of freeway between Salt

Lake City and Wendover. Because the freeway itself is only about a decade old, the new adaptive derivative must also be no older than that. In the center of the population, *A. tridentata* and *A. canescens* are sympatric. Hybrids and hybrid products, as well as the new stabilized segregant, are all present. In the summer of 1977, an actual count was made of the plants of this new form. On the roadsides of the lanes leading westward into Wendover, 17,600 plants were counted. Assuming approximately the same number on the roadside of the lanes leading eastward toward Salt Lake City, the total population consists of only about 35,000 plants. It is still rare, but as long as the highway is there there is little threat to its continuation. This portion of the freeway is mostly across empty salt flats, so grazing and other biological pressures are essentially absent. Conceivably, these robust, unique plants may be preadapted for occupying areas other than the side of the freeway, in which case they may one day find an escape from this restricted island. In any case, legislated protection is probably meaningless, despite their rarity and high intrinsic aesthetic and scientific value.

D. *The twelve-ploids*

Atriplex canescens var. *laciniata* Parish is distinguished by fruit bracts that are thin and lacy. It is common sporadically in much of the Mojave Desert, with extensive populations near Barstow, California, and around the Salton Sea. It is apparently an allopolyploid derived from the hybrid *A. canescens* × *A. polycapra*.

Although this extraordinary species is now well established and apparently in no need of protection, it hybridizes freely with both *A. canescens* and *A. polycarpa*, yielding numerous novel progeny, each one of which is rare. Although most are aneuploids, some of them may be preadapted for habitats yet uninhabited.

Parallel examples can be drawn from other groups of saltbushes and probably from many other desert plants. Rare taxa and endangered taxa are commonplace in these rapidly changing environments. The problem then is not one of finding them or defining them, but, rather, understanding them. Not until we know their biology and their genealogy can sound decisions be made concerning their management. Large, genetically uniform populations may be, biologically, much more endangered than smaller but heterogenous populations. Genetically they are certainly more rare.

In terms of management then, it is far more important to identify rare and endangered genotypes than rare species. In some instances species having abundant genetic variation and few individuals may be much less endangered than species having limited genetic variation, albeit many individuals.

CONCLUSION

It appears clear, therefore, that the meaning of "rare and endangered" must extend beyond mere head counting. Abundant individuals may not always mean abundant and therefore secure genotypes, and vice versa: species represented by only a few individuals may be so rich genetically that their continuance, under almost any normal environmental assault, is essentially certain. Equally important, in view of the cost to ecosystems, to human society, and to other contemporary organisms, some rare forms may not warrant preservation at all. A sterile, weak polyhaploid derivative with essentially no potential for amounting to anything of value cannot justify protective measures merely because it is rare and endangered. A dinosaur pet, as fun as it might be to have, would be prohibitively costly just to feed—let alone to house and to exercise. On the other hand, new exciting infant forms with rich potential for high aesthetic, biological, economic, or academic values should be encouraged and their establishment and growth accelerated. To tell which of the rare forms are coming into existence and which are going out requires intimate knowledge of their biology and genealogy. Simply enumerating named taxa which are rare is not enough. If we are going to meddle in the evolutionary process, let us do it intelligently. Otherwise it would be better that we do not meddle at all.

QUESTIONS FOR DR. STUTZ

Q. Howard, how are you going to choose which ones you are going to save?

A. I would expect that value judgements will be used just like we use them in creating priorities in every decision we make in life. We categorize them. So I think that if I were given an array of choices I could make that decision on the basis of relative value. But it's not going to be a simple recipe. It's going to be based on intimate knowledge of the species being considered.

Q. But you mean they are going to be entirely based on man?

A. In the absence of that, then we would have to do as has been suggested by several, including Dr. Stebbins and Dr. White. We simply maintain the ecosystems, refrain from imposing our personal preferences, and let natural selection make the choice. Then we're removed from that dilemma. I think, in many cases, ultimately that's what has to happen. It's obvious we cannot put everything into a wilderness protected area, but we need to have preserves. We need to provide opportunities where the evolutionary process can proceed without our intervention. On the other hand, there are situations where we must evaluate. We will have to decide whether to plow that field or to put in that hydroelectric plant. When it is necessary to impose human decisions, then we must also impose human value judgements. At that point we need all of the biological information we can possibly get to make those decisions. They must not come simply from a knowledge of numbers of individuals alone.

Dr. Stebbins: First I think this is a fascinating topic, but I'd like to bring this whole question of preserving or not preserving into the context of what you said about intelligent meddling with evolution. I think in this case, if we're going to understand evolution, we want to make it go. After all, the engineer doesn't just look at what electric motors did in the past, he makes new ones. Now in the case of the examples you have in both your *Purshia-Cowania* and your *Atriplex*, it impresses me that these obviously recent populations have not yet fitted in to any particular ecological niche. The way to save them, in my opinion, is to gather large numbers of seeds and meddle just a little bit by finding out just what kind of ecological niches they prefer. Those that aren't likely to be disturbed will be happy homes for these things and will then lead on to something new and still different. I'm particularly interested in this stabilized *Purshia* colony in that connection. You should go up there and ask permission from that rancher to get all the seeds you can and grow them somewhere along the margin there and just see if you can't find a place where it will be more than just a puny little population. In the case of your Wendover freeway, heavens knows there are miles and miles and miles of freeway that have nothing but *Salsola kali*, for instance. Wouldn't it be nicer to have this thing rather than Russian thistle or halogeton?

A. The answer is in the affirmative. I'm glad you brought that into perspective, Dr. Stebbins, because we have another great opportunity before us today which needs to be exploited. That is the sudden availability of new environments provided by mining operations in which we can do this very thing. Dr. Frischknecht of the Forest Service Shrub Laboratory is working on preparing plants which will be able to tolerate oil-shale refuse dumps. Also with strip mining, there are brand new islands made available and new areas in which we can do just exactly as Dr. Stebbins suggested. We can introduce gene pools into these new arenas and watch them evolve. We can monitor the evolutionary changes and we can get a record of evolutionary dynamics like we've never been able to before. We need to cooperate with industry and use their by-products to help us learn more about succession and evolution.

Dr. Stebbins: Let me just mention this. I think it's novel, but I don't know how many of you know about it. If you have read the books of the marvelous scientific philosopher, Rene Dubois, he has made the comment that we Americans are too wilderness oriented because we, or our ancestors, were brought up in or near pioneer habitats and wilderness, whereas Dr. Dubois was brought up in the vicinity of Paris. He knows country as cultivated land, as well-manicured forests, and sees the beauty in that. Isn't there some justification in our thinking in terms of producing a pleasing landscape of human manufacture from many of the areas which are just junk now and, at the same time, of course, preserving the wilderness?

Dr. Deacon: A couple of comments, one fairly specific. It is possible to include unnamed entities. I think that's one of the criteria that need not be met. The listing process that I've been involved with has something like over 10 percent unnamed taxa.

Dr. Stutz: How are they listed? With a number?

Dr. Deacon: They're simply referred to as a subspecies with a common name that's distinctive or unique to that group. In other words, what is necessary is to realize that it is unnecessary to actually go through the process of naming.

Dr. Stutz: This entity, for example of *Purshia-Cowania*. I suppose we'll need a handle before it can even get on the roster. That was my only point.

Dr. Deacon: Not the formal scientific name. But more serious than that, in my view, was the illustration of the coyote/rabbit: if you save one, you're likely to save the other. It's the same sort of illustration that Congressman McKay used with respect to the Colorado squawfish eating the humpback chub. The point is, if you save an evolving ecosystem you save all parts of it. Just because you kill an individual doesn't mean you kill the species so that the evolution of predator/prey is what must be preserved. I would hope you might reconsider using that illustration.

Dr. Stutz: I already have.

Dr. Deacon: The other point I would like to make in that respect is that certainly the consideration of value, which is the main point of your talk, is really the most difficult thing we have to deal with here, and when you come to the process of involving economic value, it looks like one of the most fruitful possibilities for consideration. The discussion pres-

ented so nicely to us yesterday by Dr. Spencer is perhaps one of the most optimistic I've heard presented here from the standpoint of the pressure already in existence. I think he represented to us the changing social values that are in fact forcing us into the changes necessary for us to establish "a worldwide sensible economic system."

Mr. Clement: This is a fascinating evolution in refining our expression of what we're concerned about, and let me add one more fact: distinguishing between economic and fiscal valuation. Most of what we call economic is fiscal, private concern about economic return. and when you come to valuing in a broad sense, all values are economic, because we're dealing with scarce resources, whether they're material, aesthetic, or spiritual.

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SOME REPRODUCTIVE AND LIFE HISTORY CHARACTERISTICS OF RARE PLANTS AND IMPLICATIONS OF MANAGEMENT

K. T. Harper[1]

Abstract.— Analysis of the vascular floras of Utah, Colorado, and California suggest that a syndrome of life form and reproductive characteristics separates rare and common species. Woody plants are heavily underrepresented, and herbs are overrepresented on the official lists of endangered and/or threatened plants of the floras considered. Few of the rare species are descended from wind-pollinated ancestors, but instead are derived from insect-pollinated stock. Theory suggests that many of the rare taxa will ultimately be shown to be self-pollinated. The date show a tendency for rare species to be better represented among taxa having bilaterrally symmetrical as opposed to radially symmetrical flowers. In aggregate, the results suggest that most rare taxa are equipped for rapid exploitation of small, unusual habitats. Because many rare taxa appear to be dependent on insects for reproduction, their survival depends not only on appropriate physical habitat but also on healthy pollinator populations. Reproduction of outcrossed taxa will be handicapped by road dust and other sources of atmospheric particulate which might foul stigmatic surfaces. Self-pollinated taxa may have little generic variability and thus be especially sensitive to environmental modifications. Because most rare taxa are dicotyledonous herbs, herbicides such as 2, 4-D which have been widely used in vegetation management for control of broadleafed plants can be expected to have highly deleterious effects on populations of rare species in the target area.

The goal of management in any discipline is control of the components of the system under consideration. The components of any system can be controlled only if their characteristics are understood. Once the critical characteristics and their dynamics through time are known, control strategies can be formulated and tested.

Currently we know a great deal about which plant species are so uncommon that their existence could be endangered by even moderate natural or manmade changes in the environment. We know less about the size and distribution of the populations of most rare species. Even less is known about the habitat requirements of the individual rare species. But perhaps our greatest ignorance concerning rare taxa relates to the specifics of their life history and reproductive biology. Before such taxa can be successfully managed, managers must understand the life cycle, longevity, and reproductive habits of each.

In this paper, I will examine various life form, longevity, and reproductive characters of endangered and/or threatened plant species of three states of the western United States: California, Utah, and Colorado. The incidence of a given characteristic among species listed as endangered or threatened in a particular state (U.S. Department of Interior 1975) will be compared to the incidence of that character in the entire seed plant flora of that state. By the use of appropriate statistical tests, characteristics that are over- or underrepresented among rare taxa can be identified, provided the incidence of each character is known among both rare taxa and the full flora of the state.

Methods

The basic data for this paper have been drawn from Munz and Keck's (1973) flora of California, a Soil Conversation Service Checklist of Utah plants (no date given), Harrington's (1964) flora of Colorado, and the U.S. Department of Interior's (1975) initial listing of endangered and threatened plant species. Characteristics of the individual taxa have been drawn from species descriptions in the floras, examination of herbarium material, and personal experience. Some taxa in all states could not be characterized adequately and were thus omitted from consid-

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eration (this deficiency was particularly serious for the California flora).

Suffrutescent (woody rooted herbs) taxa are treated as perennial herbs. Annual and biennial taxa were combined for the purposes of this paper. Mode of pollination (wind, water, or animal) was inferred for each taxon from floral structure, degree of exertion of stamens and stigmas, and published reports. The accessibility of the pollen and/or nectar to the average animal visiting the flower was deduced from floral structure. Flowers were considered to have restricted access to animals if they possessed any of the following characteristics: (1) petals, sepals, or calyx tube fused into a long (over 3 mm) tube of small diameter (as in some *Gilias*, *Oenotheras*, or *Cirsiums*), (2) nectaries positioned in tubes that extend away from the reproduction organs (as in *Delphinium* or *Aguilegia*), and (3) separate sepals and petals that are so positioned as to stand rigidly erect forming a narrow, false tube around the reproductive organs (as in *Erysimum*, *Streptanthus*, or *Vicia*). Not all sympetalous taxa were considered to have restricted access flowers. For instance, some *Campanula*, *Valeriana*, and *Kalmia* species were classified as being open and freely accessible to pollinators. Although composite flowers that include both ray and disk flowers could be considered to include both radially and bilaterally symmetrical components, I have classified such flowers as radially symmetrical. Composite flowers consisting of ray flowers alone have also been categorized as radially symmetrical in this study.

For the purposes of this paper, I have assumed that characteristics that are overrepresented among rare taxa (in comparison to the flora from which they have emerged) impart some survival advantage to the rare entity. Conversely, I assume that characteristics that are underrepresented put rare taxa at a survival disadvantage. It will be recognized that the foregoing assumptions are based upon yet another assumption, namely that most taxa that are designated as endangered or threatened are relatively recent in origin. This latter assumption implies that the rare taxon is commonly possessed of a suite of characteristics that permit it to be successful in spite of small populations and restricted habitat. I also recognize that the foregoing assumptions reveal still another assumption inherent in the analyses presented here: if characters that are overrepresented among rare taxa are viewed as enhancing their chances of survival, it must be assumed that ancient taxa that are not well suited to modern conditions and are thus in a state of population decline are uncommon entities on the lists of endangered and threatened species. This point will be considered further in the Discussion section.

In the analyses which follow, the chi-square statistic is used to determine whether a characteristic is over- or underrepresented among the taxa listed as endangered or threatened: the incidence of that character in the regional flora is used as the basis for comparison. In such analyses, the individual species become the statistical observations or replications in the compartments of the 2 × 2 contingency tables. Relationships were declared statistically significant only when the probability value for the relationship was .05 or less.

RESULTS

Characteristics of Regional Floras

Five regional floras have been analyzed in connection with this study (Table 1). Each flora has been analyzed to give the incidence of some or all of the following characteristics: percentage of the taxa that are woody (shrubs or trees), percentage that are wind pollinated, percentage that are short-lived (annual or biennial), percentage that have flowers that do not restrict animal access to pollen and/or nectar, and percentage that are radially symmetrical. The five floras are surprisingly similar in respect to the foregoing characteristics. The most different flora in respect to the characteristics considered is that designated as Wasatch Prevalent Species. As the name implies, that list ignores species that were sampled infrequently (Ostler and Harper 1978). An emphasis on the more common species of a region seems to unduly emphasize woody and wind-pollinated species: annuals appear to be underrepresented on the Wasatch Prevalent Species list. Whether the underrepresentation of

annuals is attributable to the fact that the Wasatch Prevalent list ignores desert habitats or to some other cause is unknown.

The date (Table 1) demonstrate that woody species constitute between 10 and 15 percent of the state floras considered. In areas that are primarily desert (such as the Kaiparowits region of Utah), woody taxa may contribute almost 25 percent of the species in the flora. Wind-pollinated species contribute from 19 to 26 percent of the species in the regional floras studied. Short-lived species (annuals or biennials) furnish from 22 to 31 percent of all species in the regional floras under consideration. Animal-polluted flowers dominate all of the floras considered. In the Colorado flora and the two subsamples of the Utah flora, only from 32 to 41 percent of the zoophilous taxa have flowers that are fully opened (nectar and/or pollen readily reached by most animal visitors). Most of the zoophilous taxa in the Colorado and Utah floras are radially symmetrical (79 to 85 percent of the species).

The characteristics of the regional floras will serve as the basis against which characteristics of the endangered and threatened species of those floras will be compared. In the case of the Wasatch Prevalent Species list, no endangered or threatened species are included. Consequently, characteristics of species from the bottom third of the commonness gradient formed by arranging the prevalent species in order of decreasing average frequency will be compared with characteristics of those species which appear on the top third of the commonness gradient. Hopefully, such an analysis will reveal something about characteristics that enhance the survival of less common species.

Size and Longevity of Rare Taxa

In four of the five floras examined, woody plants are underrepresented among the endangered and threatened taxa (Table 2). The nonconforming flora is that of California: there woody plants are more common among endangered taxa than one would expect considering the number of woody taxa in the state flora, but the departure from random expectations is not statistically significant. Although most of the endangered woody species in California belong to three rapidly evolving genera (*Arctostaphylos*, *Ceanothus* and *Eriogonum*), a number of the taxa appear to be old entities that are survivors of ancient groups that are well adapted to only a few of the modern environments of the state. Species representative of apparently old, declining lineages include the following: *Cupressus goveniana* var. *abramsiana*, *Juglans hindsii*, *Lavatera assurgentiflora*, *Lyonothamnus floribundus*, *Fremontodendron decumbens*

TABLE 1. Number of species studied and characteristics of the floras considered. Floristic data sources appear at the bottom of the table. Blanks occur in the table where specific analyses have not been made.

	Flora				
Characteristic	California[1]	Utah[2]	Colorado[3]	Kaiparowits[4] (Utah)	Wasatch Prevalent[5] Species (Utah)
Size of flora	5,489	3,507	2,735	848	244
Percent woody species	14.0	10.1	11.0	22.1	21.3
Percent wind pollinated species	18.9	18.5	25.9	24.0	33.2
Percent annual or biennial species	30.7	21.9	22.7	25.1	12.3
Percent unrestricted access flowers (Zoophilous only)	–	–	40.4	32.0	39.9
Percent radially symmetrical flowers (Zoophilous only)	–	–	80.2	79.0	84.7

[1]Munz and Keck (1973)
[2]Soil Conservation Service (no date given)
[3]Harrington (1964)
[4]Welsh et al. (1978)
[5]Ostler and Harper (1978)

and *F. mexicanum*. The floras of Utah and Colorado appear not to have a significant representation of such ancient, woody taxa.

The weight of the evidences seems in favor of the hypothesis that larger (woody) species are underrepresented among rare species. Three reasons may be suggested for the underrepresentation of woody plants among rare taxa: (1) large size limits the number of individuals that can occupy any given area, (2) slower maturation rates are accompanied by lower rates of population growth, all other things being equal, and (3) long life and low reproduction rates impede the rate at which genotypes can be attuned to peculiar environments. The affect of organismal size on individuals per unit area is self-evident. The profound influence of age at first reproduction on intrinsic rate of increase of a population was demonstrated over a quarter of a century ago by Lamont C. Cole (1954 and Fig. 1). Unquestionably, the average age at onset of reproduction is older for woody plants than for herbs. Thus organismal size and age at first reproduction can be expected to combine to depress the population size of woody taxa in the early history of their existence. Theory strongly supports the concept that extinction rate is inversely correlated with population size and intrinsic rate of reproduction (Pielou 1969:17). Theorists conclude that most extinctions occur during the initial phase of population growth (Ricklefs 1979:649). Unfortulately, that is the period when slow-maturing organisms such as woody plants are at a particular disadvantage in terms of reproduction rate and population size. The chances of extinction for woody species is further enhanced by a slow rate of genetic fine-tuning to unique environments. Small, faster-reproducing (because of earlier maturation), and short-lived herbaceous taxa are almost certain to genetically adapt to new environments faster than woody taxa.

Given the advantages of small size and early reproduction, one might have expected

TABLE 2. The observed and expected occurrences of woody taxa among rare species of five floras. Expected values are based on the occurrence of woody taxa in the regional floras. A sample 2 × 2 contingency table appears at the bottom of this table. Expected values in the contingency table appear in parentheses.

	Flora				
Characteristic	California	Utah	Colorado	Kaiparowits (Utah)	Wasatch Prevalent Species (Utah)
No. of endangered and threatened species considered	234[1]	157	49	44	85[2]
No. of woody species observed	40	5	1	5	14
No. of woody species expected	33.0	15.1	5.3	9.5	22.9
Chi-square summation for the relationship	1.8	7.8	4.0	2.9	9.7
Significance of relationship	NS	**	*	NS	**

	Life form		
Species group	Herbs	Woody	Total Taxa
California endangered	194 (201)	40 (33)	234
California flora	4,721 (4,714)	768 (775)	5,489
	4,915	808	5,723

[1]Endangered species only considered
[2]No. endangered or threatened species included; species from the bottom third of the commonness gradient used instead
NS—not statistically significant
*—statistically significant at the .05 but not the .01 level
**—statistically significant at the .01 level

annual and biennial plants to be significantly overrepresented among the rare taxa. In only the California flora, however, were the short-lived taxa overrepresented, and even there the relationship fell far short of statistical significance (Table 3). In both Utah and Colorado, annuals and biennials were significantly underrepresented. Two possible reasons are offered for the results observed: (1) short life requires that a genotype by highly preadapted to the environment to be occupied, and (2) the relationship may be a taxonomic artifact because annual and biennial groups appear not to have received the close taxonomic scrutiny that numerous perennial herbaceous and wood plant groups have been exposed to. In respect to reason 1, many unique perennial herbs undoubtedly persist in potentially exploitable environments for many years before genetic recombinations are generated that permit the taxon to successfully colonize the site. Such extended periods of genetic "experimentation" would not be possible for annual or biennial taxa: in their case, the novel genotype must reach an open niche and be sufficiently well adapted to that environment to reproduce successfully in the first reproductive event. The probability that the novel genotype will be sufficiently preadapted to reproduce successfully in the potential niche during the first reproductive event is apparently small.

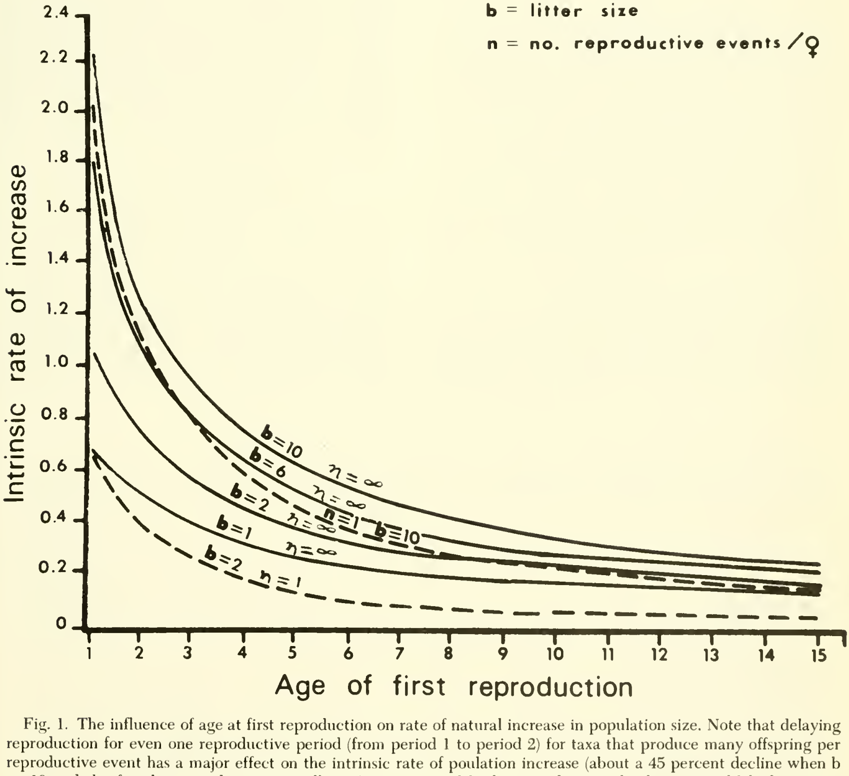

Fig. 1. The influence of age at first reproduction on rate of natural increase in population size. Note that delaying reproduction for even one reproductive period (from period 1 to period 2) for taxa that produce many offspring per reproductive event has a major effect on the intrinsic rate of poulation increase (about a 45 percent decline when b = 10 and the females reproduce repeatedly). Many perennial herbs reproduce in the first year of life, but many woody taxa delay reproduction for more than a decade. (Figure modified from Cole [1954]).

TABLE 3. Observed and expected occurrences of short-lived (annual and biennial) taxa among rare species of five floras. Expected values are based on the occurrence of short-lived taxa in the regional floras. Number of endangered and threatened species remains as in Table 2.

	Flora				
Characteristic	California	Utah	Colorado	Kaiparowits (Utah)	Wasatch Prevalent Species (Utah)
No. of short-lived taxa observed	80	15	4	9	9
No. of short-lived taxa expected	72.2	33.5	11.0	11.0	10.2
Chi-square summation for the relationship	1.3	13.6	5.8	0.5	0.3
Significance of relationship	NS	**	*	NS	NS

NS—Not statistically significant
*—Statistically significant at the .05 but not the .01 level
**—Statistically significant at the .01 level

Pollination of Rare Species

In all floras considered here, wind-pollinated taxa are underrepresented among the rare species. The relationship is significant at the .01 level in four of the five floras considered (Table 4). As Ostler and Harper (1978) have argued, wind pollination would be expected to be ineffective where species are represented by few, widely scattered individuals and where the species are small and overtopped by larger plants. Because small populations are a characteristic of all taxa listed as threatened or endangered, wind pollination would be expected to be a poor reproductive strategy for them. In addition, the threatened and endangered lists considered consist primarily of herbaceous (and thus small) organisms. Both Ostler and Harper (1978) and Freeman et al. (1979) show that wind pollination is heavily underrepresented among herbs, apparently because they are usually overtopped by woody vegetation that restricts wind flow and hinders movement of pollen to receptive stigmas.

Flower Symmetry

The data show a universal overrepresentation of bilaterally symmetrical flowers among the rare taxa of all floras (Table 5). It must be noted, however, that the values reported for California and Utah are conservative estimates only; the actual incidence of radially symmetrical flowers in those areas has not been tabulated directly

TABLE 4. Observed and expected occurrences of wind-pollinated taxa among rare species of five floras. Expected values are based on the occurrence of anemophilous taxa in the regional floras. Number of endangered and threatened species remains as in Table 2.

	Flora				
Characteristic	California	Utah	Colorado	Kaiparowits (Utah)	Wasatch Prevalent Species (Utah)
No. of wind-pollinated taxa observed	21	1	4	6	19
No. of wind-pollinated taxa expected	43.3	27.9	15.5	10.4	30.0
Chi-square summation for the relationship	14.7	33.0	12.7	2.6	12.7
Significance of relationship	**	**	**	NS	**

NS—Not statistically significant
*—Statistically significant at the .05 but not the .01 level
**—Statistically significant at the .01 level

(see Table 5 legend for assumptions for California and Utah). If the assumptions are valid for Utah, bilaterally symmetrical flowers are significantly overrepresented among rare plants there.

The overrepresentation of zygomorphic flowered species in the Kaiparowits flora narrowly misses significance at the .05 level. In aggregate, the data suggest that floral zygomorphy conveys a reproductive advantage to rare plants. That advantage perhaps lies in the fact that zygomorphy forces pollinators to approach flowers in a stereotyped way. Under such conditions (i.e., predictable positioning of the pollinator in the flower), selectin can operate to position stamens and stigmas within the flower so as to enhance the efficiency with which pollen is transferred from stamen to pollinator and from pollinator to stigma. Zygomorphy may also enhance the distinctiveness of flowers of different species and provide another cue to compliment color, size, and odor as characters that permit pollinators to distinguish flowers of one taxon from those of another. One would expect the degree of flower uniqueness to enhance fidelity between the flower and animal pollinators and thus improve reproductive success.

Restricted Access to Flowers

Taxa with flowers in which access to nectar and/or pollen rewards is restricted are overrepresented among the rare species in the three floras for which floral structure is known, but the relationship is statistically significant for the Wasatch Prevalent flora only (Table 6). Using a conservative estimate of the incidence of restricted access flowers in the California and Utah flora (i.e., the rate for Colorado from Table 1), contradictory results are obtained for California and Utah, although the results are not statistically significant for either flora. It seems reasonable to assume that mechanical barriers that restrict access of many insect taxa to nectar and pollen of a given plant species would encourage fidelity between that plant and adapted pollinators, because adapted pollinators would have greater assurance of a food reward at each visit (i.e., many potential competitors would be unable to harvest the floral rewards). The data lend only slight support to the foregoing assumption, however, and it is clear that mechanical hedges about floral rewards are much less useful adaptations to rare plants than small size, early onset of reproduction, animal pollination, or bilateral symmetry of the flower.

TABLE 5. Observed and expected occurrences of bilaterally symmetrical flowers among the animal-pollinated rare species of five floras. Expected values are based on the occurrence of bilaterally symmetrical zoophilous flowers in the regional floras except for California and Utah. Because the actual incidence of bilaterally symmetrical flowers is unknown in the latter two floras, expected values are based on the conservative assumption that bilateral flowers occur with a frequency in those floras equal to the frequency in the Kaiparowits flora (see Table 1).

	Flora				
Characteristic	California	Utah	Colorado	Kaiparowits (Utah)	Wasatch Prevalent Species (Utah)
No. of threatened and endangered species considered	214[1]	156	45	38	66[2]
No. of bilaterally symmetrical flowered species observed	52	48	12	13	12
No. of bilaterally symmetrical flowered species expected	45.3	33.5	9	8.2	9.8
Chi-square summation for the relationship	1.3	8.4	1.3	3.8	1.5
Significance of relationship	NS	°°	NS	.10[3]	NS

[1]Endangered species only considered
[2]No. endangered or threatened species included; species from the bottom third of the commoness gradient used instead
[3]Statistically significant at the .10 but not at the .05 level
NS—Not statistically significant
*—Statistically significant at the .05 but not the .01 level
**—Statistically significant at the .01 level

Discussion

Results show that the California flora behaves differently from that of Utah and Colorado in respect to the frequency of both woody and short-lived taxa. The overrepresentation of rare woody taxa in California may be explained by the relatively high incidence of apparently ancient woody taxa there. Some of the ancient woody taxa of California have been enumerated in the Results section of this paper. If there is a significantly larger component of evolutionary old taxa in California than in Utah or Colorado, the divergent results reported in Table 2 for California and the two interior states would be expected. That is, in California ancient woody species that are rare may be viewed as taxa that were once more common but have steadily lost habitat to more modern species that are better adapted to current environments. If such is the case, the basic assumption underlying this paper (i.e., characteristics that are overrepresented among rare taxa must enhance their chances of survival) would not hold. Instead, characteristics considered to be selected against among recently evolved taxa that have successfully eluded extinction may be overrepresented in older floras that are now marginally adapted to and declining in modern landscapes.

The slight overrepresentation of short-lived taxa among endangered plants of California (Table 3) is unique for the floras examined. It should also be noted that the California flora supports significantly more annual plant species than any of the other floras considered (Table 1, Harper et al. 1978). It seems likely that annual plants have been more intensively studied in California than in the interior states, but differences in taxonomic treatment among the floras considered seem inadequate to explain the differences noted in Table 1 and in Harper et al. (1978, Table 3). A suitable explanation for the apparent greater success of annuals in California as opposed to Utah and Colorado is needed, but I am unable to supply such an argument.

The fact that most of the rare taxa in the floras considered are zoophilous or, at least, derived from zoophilous stock (Table 4) suggests the need for managers to use great care when insect control programs are implemented near populations of rare plants. Unless the taxa are self-pollinated or agamospermous (producing seed without fertilization), decimation of pollinator population would adversely affect reproductive success of the plant species in at least the year of treatment.

Unfortunately, the incidence of self-pollination and agomospermy among threatened and endangered species is almost totally unknown. Consequently, all rare taxa should be

Table 6. Observed and expected occurrences of restricted access flowers among the animal-pollinated rare species of five floras. The number of endangered and threatened taxa remains as in Table 5. Expected values are based on the incidence of flowers in which access to nectar and/or pollen is restricted in the regional floras, except for California and Utah. Because the actual incidence of zoophilous species having restricted access to floral rewards is unknown in the latter two floras, expected value is based on the conservative estimate that restricted access flowers occur with a frequency in those floras that is equal to the frequency in the Colorado flora (see Table 1).

	Flora				
Characteristic	California	Utah	Colorado	Kaiparowits (Utah)	Wasatch Prevalent Species (Utah)
No. of threatened or endangered taxa observed with restricted flowers	119	99	29	26	45
No. of taxa expected to have restricted flowers	127.1	93.3	26.9	25.5	39.1
Chi-square summation for the relationship	1.3	.9	.4	.04	5.6
Significance of relationship	NS	NS	NS	NS	*

NS—Not statistically significant
*—Statistically significant at the .05 but not the .01 level

treated as obligate outcrossers until proven otherwise. This point suggests that any management act that has the potential of diminishing pollen flow between separate individuals of any rare taxon should be carefully evaluated in terms of possible reproductive impairment of that plant. Thus, construction work or traffic over unpaved roads near populations of either wind- or animal-pollinated species should be carefully controlled or curtailed completely, because dust can foul stigmatic surfaces and essentially eliminate pollination of obligate outcrossers.

A knowledge of the breeding system of all rare taxa would markedly improve our ability to make wise management decisions concerning them. As noted above, outcrossing taxa will necessitate more management restrictions than self-pollinated or agomospermous taxa. On the other hand, self-pollinated and agamospermous taxa may be far less genetically diverse and hence more easily disturbed by environmental alterations than outbreeders. Furthermore, a knowledge of the breeding systems of rare plants would help phylogeneticists to better define the probable origins of the taxa and geneticists to estimate the likely amount of unique germ plasm in given taxa (Baker 1961).

Circumstantial evidence suggest that many of the threatened and endangered plant species will be shown to be self-pollinated or agamospermous. Such reproductive habits would be expected to be selected for in rare taxa for two reasons: (1) both habits would tend to preserve unique gene combinations that adapt rare plants to their habitat, and (2) both reproductive habitats would permit solitary individuals to successfully reproduce (Grant 1971).

Finally, it is worthy of note for managers that most of the rare taxa in all of the floras considered here are dicotyledons. Thus, the broad spectrum herbicides belonging to the 2, 4-D group (dichlorophenoxyacetic acid and near relatives) that have proven so effective against broadleaved plants can be expected to be dangerous to most rare plants. Herbicides of this group have been widely used in land management programs in the past for control of undesirable species. In the future, threat to endangered species must be added to the list of constraints that must be considered when use of such herbicides is considered.

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THE IMPORTANCE OF BEES AND OTHER INSECT POLLINATORS IN MAINTAINING FLORAL SPECIES COMPOSITION

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Abstract.— Bees and other insect pollinators which are necessary for the successful reproduction of most species of flowering plants, including agricultural crops, have been ignored by our preservation efforts. This is unfortunate because bees, as low-fecundity organisms, are very susceptible to insecticides and populations are slow to recover from perturbations. Many species of bees, particularly specialized species in the western United States and the tropics, are vulnerable to extinction. With extinctions of specialized forms, generalized species, especially fugitives, are expected to increase because of their ability to utilize a variety of resources and survive beyond the confines of preserves. The possible effects of increased dominance by generalist pollinators on floral species composition is discussed.

Aside from being included in our objective to preserve existent natural diversity (Terborgh 1974), insect pollinators merit our preservation efforts because some 67 percent of extant flowering plants depend, to varying extents, upon them for reproduction (Axelrod 1960). Indeed, "pollinators are an environmental resource as critical to the long-term survival of a (plant) population as are light, moisture, etc." (Levin 1971). The adaptations for the attraction and utilization of insects by flowering plants for reproduction are impressive. They include size, color, fragrance, nectar, excess pollen, and nutrient contents, as well as morphology, positioning, and development of the floral parts (Percival 1965, Baker and Hurd 1968, Faegri and van der Pijl 1971, Leppik 1972, Proctor and Yeo 1973). In the absence of insects, most flowers as they are produced today would be maladaptive and our flora would assume a different aspect.

An example of a flora with few available pollinators is that of the Galapagos Islands, where only one species of bee and 19 species of lepidoptera have been recorded (Linsley 1966). Where pollinators are in extremely short supply it is disadvantageous to produce large, attractive flowers. Instead, we expect selection for wind pollination or autogamy with a concomitant reduction in conspicuous flowers (Rick 1966). In fact, there are few brightly colored flowers in the Galapagos; most are drab, and "endemics tend to have reduced corollas" (Rick 1966). In pollination tests with 18 species from seven families, Rick found a high incidence of autogamy: 13 species self-pollinated automatically and one was self-compatible. Results from four other species were inconclusive. Linsley et al. (1966) have speculated that successful invasion of the islands may have been restricted to those plant species which are either wind or self-pollinated or compatible with available pollinators. Thus, the Galapagos flora is probably less diverse than it might have been had the pollinator diversity been higher.

Bees are the most important of insect pollinators. Except for masarid wasps and a few beetles, only bees depend exclusively upon pollen and nectar for food throughout their life cycle. Their coevolution with flowering plants is manifest in the many morphological, behavioral, and physiological adaptations which make them more efficient at flower utilization (Linsley 1958, Percival 1965, Baker and Hurd 1968, Stephen et al. 1969, Faegri and van der Pijl 1971, Proctor and Yeo 1973).

In many cases the reciprocal adaptations between particular bee and plant taxa have

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become rather specialized. Within the genus *Penstemon*, for example, species of the Series Graciles are adapted for pollination by bees of the genus *Osmia* (Crosswhite and Crosswhite 1966). Tropical orchids attract males of particular species of bees of the genus *Euglossa* by specific fragrances (Williams and Dodson 1972). *Pedicularis* species are pollinated only by bumble bees (e.g., Macior 1977). The pollen and nectar of the poisonous range plant death camas (*Zigadenus* spp.), though deadly to honeybees (Hitchcock 1959), are utilized by the oligolectic bee *Andrena astragali* Viereck & Cockerell, which also pollinates the plant (pers. obs.).

In addition to our native flora, many important agricultural crops, including cole crops, orchard fruits and nuts, bushberries, strawberries, some citrus fruits, sunflowers, cucurbits, alfalfa, and red clover either require insect pollinators for seed set or set more seed in their presence (Free 1970, McGregor 1976). Although most crop pollination is presently accomplished by honeybees, reports of native bees visiting flowers of agricultural crops are common (Free 1970, McGregor 1976), and endemics are undoubtedly responsible for some, as yet undetermined, percentage of crop pollinations. Two solitary species have replaced the honeybee as the preferred pollinator of alfalfa in the northwestern United States (Bohart 1972b), and another species, *Osmia lignaria* Say, shows considerable promise as a pollinator of pome crops (P. F. Torchio, pers. comm.). Native bees will probably play an especially important role in the pollination of sunflowers, a rapidly increasing native crop (F. D. Parker, pers. comm.). The preservation of exotic bees will be important as we increase our agricultural acreages of introduced crops and seek to import pollinators that have coevolved with those crops. For example, the primary pollinators of alfalfa in the northwest, *Megachile rotundata* (Linnaeus), is an exotic species native to Europe.

Of Grasshoppers and Bees

During the summer of 1978 a news release in the *Laramie Daily Boomerang* announced that a joint federal, state, and locally funded insecticide spray program would be conducted in northeastern Wyoming to control grasshopper populations that had exceeded economically safe levels. I paraphrase the last segment of the news release: "Those who are concerned about bee populations in the area please note that all bees will be removed before spraying is conducted." This is quite an impressive feat considering that Wyoming has a minimum of 660 species (Lavigne and Tepedino 1976), all but one of which evolved with the native flora. The single exotic, *Apis mellifera*, the honeybee, was, of course, the species that was moved.

At the time insecticide was applied there were probably between 25 and 50 species of bees in the area. Unfortunately, no studies assessing the affect of spraying were undertaken, but other work has shown severe pollinator depletion following insecticide application (Kevan 1975, Plowright et al. 1978, Robinson and Johansen 1978). Because of their susceptibility to pesticides (Johansen 1977), wild bee populations were probably decimated.

The rate of recovery of an animal population whose numbers have been drastically trimmed is positively correlated with the intrinsic rate of increase of that population (May et al. 1974). Though females of many insect species produce hundreds or thousands of offspring, each of which receives little or no parental care, bees have developed a contrasting strategy. Bees produce few offspring and expend considerable effort to insure the survival of each. Greenhouse studies at the USDA Bee Biology and Systematics Laboratory with several solitary species, under conditions of excess bloom and without natural enemies, show that maximum fecundity averages 15–20 offspring per adult female. In the natural environment, where bloom is only occasionally superabundant and competitors, predators, and parasites abound, fecundity must be much lower. Because of their low fecundity, bees recover slowly from bouts of insecticide spraying or other perturbations. Plowright et al. (1978) estimated that three to four years would be necessary for bumble bee populations to return to prespray levels. Such estimates assume cessation of spraying and a continuously favorable environment. Periodic spraying or long periods of weather

unfavorable for flight would further slow recovery rates.

The low fecundity of bees has other effects. Smaller populations are more vulnerable to local extinction by random events (McArthur and Wilson 1967). If bee populations are periodically or consistently disturbed, numbers will remain below carrying capacity for extended periods, and populations will become more prone to random extinction. The resistance to insecticides developed rapidly by many pest species is partially due to the great genetic variability contained in the prodigious numbers of offspring produced by single females (Georhgiou 1972). Because of reduced fecundity, bees may be less likely to develop resistance than other insect species. Indeed, resistance to insecticides is unknown in bees.

The example of the bees that were not moved (or even considered) illustrates our philosophy of preservation. We have emphasized the preservation of species that are "useful," closely related, or obvious to man. We overlook the functionally important organisms that are frequently small and more subtle in their actions. For example, insects, the most influential of terrestrial animals (man aside), whether judged by numbers of species, individuals, or biomass, are represented by only eight threatened and endangered species, all butterflies. Yet there are over one million described insect species and at least as many awaiting description. The base of the trophic pyramid, plants, are represented by a mere 22 species. In comparison, 588 species of vertebrates appear on the latest Threatened and Endangered Species List (U.S. Department of the Interior 1977). A trend is evident even within the class Vertebrata: 7.0 percent of all mammals are threatened or endangered, 2.5 percent of all birds, and 1.2 percent of all reptiles and amphibians—but only 0.3 percent of all fish. It is time that we attend to the preservation of functionally important organisms without backbones, many of which make vertebrate existence possible.

The Rarity of Bees

As pointed out by Bohart (1972a), the effect of man on wild bees has been both positive and negative. Overall, however, bee populations are probably in decline due to habitat destruction and to our increasing dependence on insecticides and herbicides. But even this assessment is tenuous because of the paucity of hard information. There are over 20,000 extant species of bees, and we know almost nothing of all but a handful of them. Our knowledge of tropical species is especially poor, but we can guess that with man's rapid destruction of tropical habitats many species will be lost. Even in the western United States where bee diversity is very high (Linsley 1958) we do not know how many species, if any, have become extinct recently or how many may be threatened. Indeed, it is likely that the bee fauna of western North America harbors many undescribed species. For example, in two years of collecting on shortgrass prairie in southeastern Wyoming, I recorded over 200 species, 5–10 percent of which are new to science.

We do know from museum records that many species are rarely collected. Lists of such species could be compiled, but are these species truly rare (Drury 1974), or simply underrepresented in collections? Two of the many possible examples illustrate this problem of identifying endangered bees. Until 1975, *Osmia tanneri* Sandhouse, a mason bee, was represented by a single male specimen collected in 1928 in the Raft River Mountains of Utah by Vasco M. Tanner. F. D. Parker (1975) rediscovered the species nesting near Wellsville, Utah, and in 1978 Tepedino and Boyce (submitted) found a large nest in a lawn in Laramie, Wyoming. Fifty years after the species was discovered we know little more than that it still exists and it builds mud nests under rocks.

The genus *Dufourea*, a ground-nesting group, provides numerous examples of species with restricted distributions. G. E. Bohart of the Logan Bee Laboratory is currently studying the systematics of this group and has kindly furnished the following information. Over half of the 70 known species are restricted to California, and many of these have been recorded from only a single county. An undescribed species is restricted to the hills west of San Bruno, an area which is likely to undergo considerable development in the near future. Another undes-

cribed species is represented by two specimens collected in Joshua Tree National Monument. *Dufourea macswaini* Bohart has been collected only from the flowers of *Clarkia purpurea* in Madera County. Ten to fifteen other species have restricted, allopatric distributions on the west slope of the Sierras. With the continuing increase in population and habitat destruction in California, it is likely that many of these rare species will disappear.

For a single region, Wyoming shortgrass prairie, we know that species abundance curves for bees show the typical insect pattern (Williams 1964): there are a few abundant species and many rare ones (Fig. 1). Some of this rarity is undoubtedly due to inadequate sampling or to the capture of errant individuals which are abundant at higher elevations 5–10 km away. However, many of these species may be fugitives (see below), whose local abundance shows much spatiotemporal variability.

The Island Effect

With increasing loss of habitat, many plant and pollinator species will be confined to island preserves of restricted size surrounded by unsuitable areas. The number of species supportable will be determined by size of the preserve and the distance to other preserves, expressed through immigration and extinction rates (MacArthur and Wilson 1967). Such "mainland island preserves" and their appropriate design have been the subject of much discussion (Diamond 1975, 1976, Wilson and Willis 1975, Simberloff and Abele 1976, Whitcomb et al. 1976, Pickett and Thompson 1978), but, in general, preserves should be as large as possible so as to reduce the probability of extinction of resident species. Large size preserves become more important as suitable surrounding habitat diminishes, because immigration rate decreases with increasing distance from potential source areas.

The islandlike nature of preserves will also influence the kinds of plants and pollinators which can survive. Preliminary studies of the Galapagos and other islands (Carlquist 1974) suggest that a depauperate pollinator fauna restricts successful colonization to autogamous and anemophilous plant species and to those compatible with the pollinator fauna. On our size-restricted mainland islands the flora and fauna is, for the most part, already present. The questions are: Which portion of the pollinator fauna is most vulnerable to extinction, which species or species types are most likely to recolonize, and how will this affect plant community composition?

Plant community composition can be altered by differential changes in any of the numerous selective pressures that operate at each stage in the life cycle of component plant species (Harper 1977). Reduction in seed set, because of changes in the pollinator fauna, is but one way to alter the abundance of a given plant species. Nevertheless, pollination is a critical step in the production of the sporophyte generation. Other factors that affect the relative success of a plant species, and ultimately community composition itself, operate subsequent to pollination. If the gametophytes are not brought together, no other factor is important.

The effect of a change in the pollinator fauna on particular plant species will depend upon how specialized in pollinator requirements a plant is and which species of pollinator(s) has been lost. Specialized species have long been thought to be less adaptable to changing conditions and therefore more vulnerable to extinction (Rensch 1959). Recent evidence supports this idea (Drury 1974, Case 1975, Diamond 1975, Wilson and Willis 1975). A plant which has evolved with a specific pollinator is doubly disadvantaged because it may become endangered through direct means, e.g., habitat loss, or by disappearance of its pollinator. Specialized pollinators are exposed to similar risks.

Certain specialized pollinator species will require large tracts of land for their survival. Traplining species (Janzen 1971), which may be abundant in the tropics, require large areas for successful foraging and probably would not survive on smaller preserves. Plant species dependent upon traplining pollinators for outcrossing are also vulnerable.

If floral production by the food plant of a specialized pollinator is spatiotemporally variable, then reserves of a size sufficient to incorporate such variability will be necessary

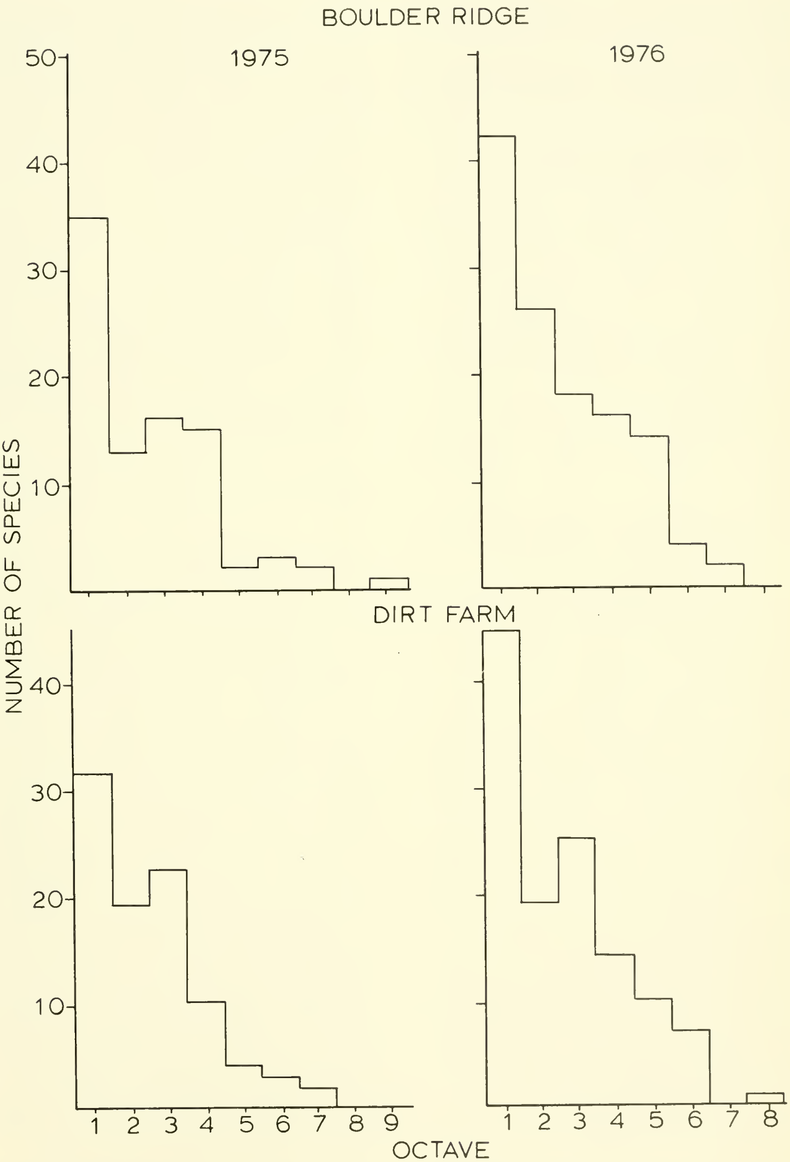

Fig. 1. Species abundance distributions for the bee fauna on two rangeland sites in southeastern Wyoming. Each site-year is treated separately. An octave is equivalent to $\log_2$ number of individuals. All curves, except Boulder Ridge 1975, fit a lognormal distribution.

if pollinator and plant are to be preserved. Little is known about variability in flower production between years in the same area or between areas within years. On shortgrass prairie, spatiotemporal variability in flower production is substantial (Tepedino and Stanton, in prep.). Other evidence from the literature tentatively suggests that many other regions exhibit similar variability between years in floral phenology (Tepedino and Stanton, in prep.) and that specialized plant species are no less variable than others (Tepedino and Sauer, unpubl. ms.). If we are to design natural reserves with necessary minimum dynamic area (Pickett and Thompson 1978) to accommodate pollinators, much additional data on variability of flower production by specialized plant species will be required. In general, however, smaller reserves are probably more stressful to specialist plants and pollinators than to generalized species.

Regions which harbor high proportions of specialized pollinators are especially prone to species loss. The Sonoran Desert, where Neff et al. (1977) estimated that 33–50 percent of bee species are specialized, is one such region. Indeed, much of the bee fauna of a substantial portion of the western United States, as well as other arid regions, may be specialized (Linsley 1958, Moldenke 1976). If specializations of euglossine bees are indicative of bee-plant relationships in the American tropics (Janzen 1971, Williams and Dodson 1972) then a substantial portion of the tropical flora and fauna may be jeopardized. Alternatively, the numerous species of stingless, social bees in the American Tropics, most of which are probably generalized in flower utilization, may indicate lower diversity of floral reproductive adaptations than we currently think. Many species of canopy trees, for example, produce large numbers of small, nonspecialized flowers (Frankie 1975) that superficially appear capable of utilizing a variety of insect species. We will need more data on tropical pollination systems before an adequate assessment can be made.

Most plant and pollinator taxa are not so specialized. For example, on Wyoming's shortgrass prairie most plant species are visited by many potential bee pollinators and most bee species utilize several flower species (Fig. 2). Moldenke (1975, 1976) reported similar results for several plant communities in the western United States. On shortgrass prairie, flower and pollinator usage also varied widely between years. Using Sorenson's presence-absence similarity index (Mueller-Dombois and Ellenberg 1974), we compared the plants foraged upon for each species of bee between years and, also, the pollinators which visited each species of plant in each year (Fig. 3). Most species of bees and plants were variable in their resource usage (low similarity values), especially at the Boulder Ridge site where floral variation was also greatest (Tepedino and Stanton, in prep.). Finally, most bee species also utilized a variety of flowers during particular foraging trips. Identification of pollen species from loads carried by bees showed that over 65 percent of all individuals had visited two or more plant species on a given trip and that 46 percent had visited more than three plant species.

Generalized bees are less vulnerable to extinction than specialists for reasons related to their ability to utilize a variety of flower species. First, unlike specialists, generalists will not become endangered because of the disappearance of a specific host plant. Second, the probability of a species becoming extinct due to random events increases with decreasing population size (MacArthur and Wilson 1967). Populations of resident generalists should be better buffered against wide fluctuations in numbers because of the wider potential resource base. In particular, population size of generalist species during unfavorable periods of bloom should be higher than that of specialists and therefore less prone to extinction. Finally, generalists are less dependent upon the size of preserves than specialists, because it is more likely that surrounding areas will contain plants which are suitable to them. In effect, the area suitable to generalists will almost always be greater than that for specialists and will extend beyond the confines of a preserve. Preserves should be designed with the minimum dynamic area (Pickett and Thompson 1978) necessary for specialist survival in mind.

One particular group of generalized bees that is least likely to be affected by habitat loss and disturbance is the fugitive species

contingent. Hutchinson (1951) proposed the term *fugitive* to describe species that avoid vying for limited resources with superior competitors by dispersing to localized patches of resource abundance where competition is temporarily relaxed. Fugitive bee species should be especially evident in habitats where floral resources are spatiotemporally unpredictable such as shortgrass prairie (Tepedino and Stanton, in prep.). Indeed, in these studies on shortgrass prairie, we found that less than 30 percent of the approx-

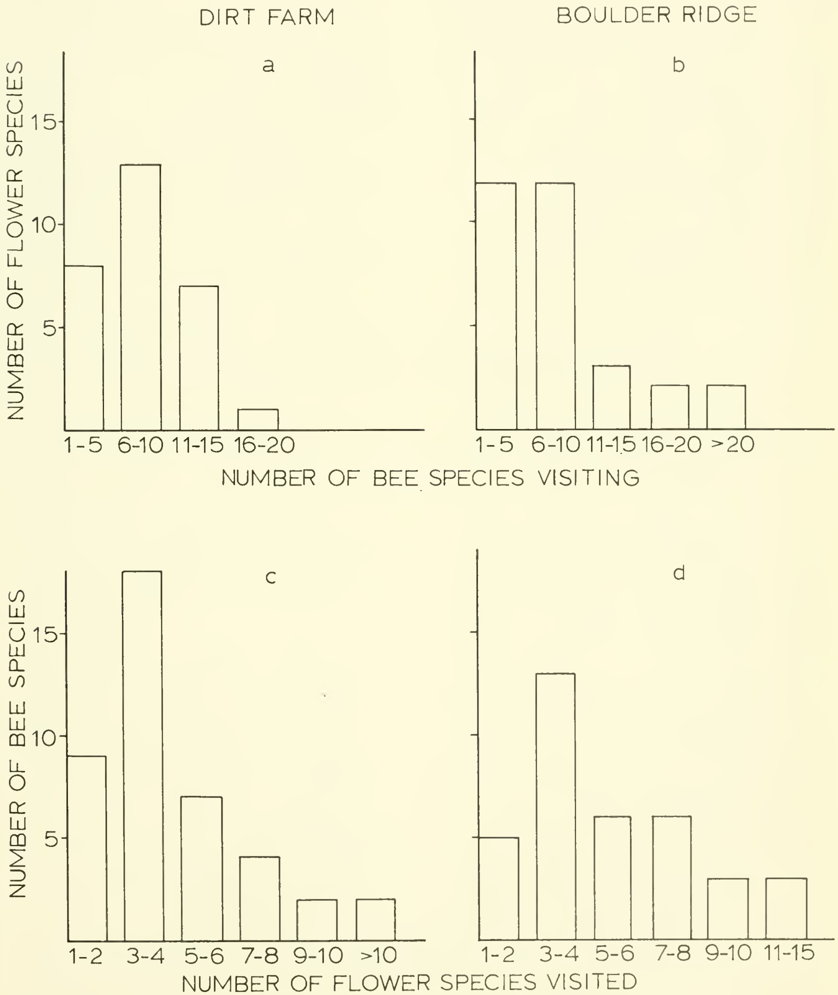

Fig. 2. a,b—Distribution of shortgrass prairie flower species according to the number of bee species visiting them over two years on two sites in southeastern Wyoming; c,d—distribuion of bee species by the number of flower species utilized.

Fig. 3. a,b—Distribution of resident bee species by their similarity in flower utilization between consecutive years on two shortgrass prairie sites; c,d—distribution of flower species by their between-year similarity in bee species visiting them.

imately 150 bee species recorded on each of two sites could meet such relaxed requirements for residency as ≥3 individuals on a given site in each year. Most species were either present in very low numbers in each year or were abundant in one year and absent in the other. The percentages of total individuals collected that were nonresidents varied from 8.6–40.4 percent at the Boulder Ridge site and from 16.9–26.8 percent at the Dirt Farm. Although some nonresidents were undoubtedly incidentals from other habitats, the large number of species and individuals in this category suggest the presence of a substantial fugitive species contingent.

With diminution of native habitat, fugitive species will comprise an increasingly dominant element of the bee fauna. Unlike specialized bees and to a lesser extent resident generalists, fugitives will be uninfluenced by size of reserves because of their tendency to disperse and their ability to utilize a variety of floral resources. Fugitives will have little difficulty succeeding outside reserves because of the many patches of floral resources available along roadsides, in agricultural fields, backyards, etc. Indeed, these are the kinds of situations to which fugitives are adapted (Wilson and Willis 1975, Diamond 1976, Whitcomb et al. 1976). As resident bee species gradually disappear from reserves because of random extinctions of their relatively small populations, they will be replaced not by other immigrants of the same species but by fugitives.

The affect on the flora of losing generalized pollinators is difficult to assess. It is tempting to claim that many generalists are functionally redundant and therefore expendable; if lost, their pollinatory activities will be assumed by others. Such a justification for nonpreservation is potentially insidious because we have virtually no information on the relative efficiencies of different pollinators on particular plants or of a single pollinator on several plant species (Primack and Silander 1975). Conversely, several studies have now shown that plant and pollinator diversity are significantly correlated (Heithaus 1974, Moldenke 1975, del Moral and Standley 1979). A reduction in the diversity of either plants or pollinators may lead to a reduction in the diversity of the other.

There are reasons for believing that functional redundancy is minimal, and that elimination of generalized bee species as well as specialists can lead to differential alterations in seed set between plant species. First, some bees may collect nectar and/or pollen from certain species of flowers without pollinating them (Grant and Grant 1965, Faegri and van der Pijl 1971, Percival 1974, Tepedino 1975). Small species and certain bumble bees are more likely to fall into this "robber" category (Faegri and van der Pijl 1971). Their categorization as potential pollinators of those plants from which they rob is misleading and can lull us into a false sense of redundancy. We must be careful to distinguish between visitors and pollinators to arrive at intelligent conservation decisions, and this will necessitate much additional study. Nor is it valid to conclude that because a generalized pollinator robs the resources of one plant species it is without value as a pollinator of other species. Many bumble bees rob nectar from certain plants but are important pollinators of others (Faegri and van der Pijl 1971).

Secondly, although generalized bee species utilize a broader subset of available floral resources than do specialists, the foraging of any given species does not include all available flower species. Neither are the visits of any particular species proportional to the abundance of flower species available (Tepedino and Stanton, in prep.), nor are bee species equally efficient at pollinating all plant species visited. The extinction of a single pollinator species will reduce visitation rates to certain plant species in the community to some unknown degree. Without evidence, it seems overly optimistic to assume that such a reduction will be compensated for by remaining species. Further, even if visitation rates by other species do compensate for the lost pollinator, there is no basis for assuming that the efficiency of such visits is equivalent to that of the species which have disappeared. For example, in a study of four solitary bee species visiting alfalfa, Batra (1976) found that, although all gathered nectar and pollen and accomplished pollination, they did so with varying degrees of proficiency. Two species spent more time than others foraging on hidden flowers, one visited many more flowers which had already been

pollinated, etc. The species varied during morning foraging from 0.8 to 3.68 pollinations per minute. The effect of removal of one of these pollinators upon seed set would depend upon which species was removed. If we extend the results of this simple greenhouse study to plant communities in the field, we gain an impression of the unknown complexities which we are tampering with.

It seems clear that plant species that depend upon particular bees for their reproduction will experience severe selective pressures to evolve autogamy (Levin 1972) or wind pollination or to realign their floral morphologies to take advantage of remaining pollinator species. For many specialized plants such adaptations will be impossible (Levin 1971, Baker and Hurd 1968) and their extinction is likely. While it is not uncommon to develop facultative autogamy from obligate outcrossing (Baker 1959), selfing may be least advantageous in environments with low predictability such as shortgrass prairie (Solbrig 1976). In such regions plant species that solve pollination problems with obligate autogamy may become extinct more gradually.

As specialized pollinators are replaced by fugitives, more generalized plant species may become endangered because fugitives are relatively inconstant foragers. Several theoretical studies provide similar results for situations in which plant species compete for pollinator visits: if pollinator constancy is proportionate to floral abundance, minority species will receive fewer pollinating visits than more abundant species and will eventually disappear (Levin and Anderson 1970, Straw 1972, Waser 1978). Even worse, if pollinators show disproportionate preference for more abundant species, then less abundant species will approach extinction more rapidly.

There is little doubt that in North America we will lose many bee species and other pollinators as well, particularly from the western states. As a result of these extinctions, we will probably see some gradual transition in the composition of our flora. Floral change will be most obvious and far-reaching in desert, chaparral, and alpine ecosystems, where the percentage of insect-pollinated plants is high (Moldenke 1976). In forests and grasslands, where the dominant plant species are wind pollinated, changes will be more subtle and less easy to predict.

Obviously, the key to slowing the rate of pollinator and plant extinction is habitat preservation. We need to set aside as much land as we can possibly afford in the form of greenbelts, parks, and reserves of various sizes. In addition, we should encourage the use of local plant species as ornamentals in backyards and gardens instead of the sterile creations of seed companies. Local plant species are frequently as esthetically pleasing and, because they are adapted to the region, require less care and expense in the form of fertilizers, water, etc. It is also quite simple to provide nesting material for some solitary bees in the form of pine wood blocks or scraps with holes drilled in them (Krombein 1967). These can be set out on posts in backyards as are bird houses and feeders. The species which will utilize these trap-nests are not at all agressive and will sting only when handled. In short, every little bit will help and, unfortunately, we need all the help we can get.

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ENDANGERED SPECIES: COSTS AND BENEFITS[1]

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Abstract.— Biologists are often placed in the difficult position of defending a threatened habitat or animal with vague reasoning and faulty logic, simply because they have no better rationale at their immediate disposal. This places them at a distinct disadvantage and literally at the mercy of resource exploiters and their easily assignable dollar values. Although the initial dollar cost of delaying or precluding "developing" may be significant, the long-term benefits of saving the biological entities which might otherwise be destroyed are likewise great and are measurable in concrete terms which society is only now beginning to appreciate. Case histories are presented, a more profound rationale is explained, and the environmentalist is challenged to make his case sufficiently effective to reverse the current exploitive trends which threaten so many of earth's life forms.

The land and water developers, mineral extractors, and other resource users which burgeoned nationwide (especially in the West) following World War II placed agency resource managers in a new and uncomfortable position. Whereas there once had been sufficient land and water for everyone, including our plant and animal species, we suddenly found ourselves entering into what seemed (on the surface, anyway) an "us or them" situation. Backed into a corner, biologists and administrators found themselves searching frantically for values with which to defend their trust against the hard dollar figures of the exploiter.

Nowhere has this concept been more apparent than in our efforts to preserve threatened and endangered species. When pitted against a potential development project involving the expenditure of millions of dollars, the environmentalist has been forced to bolster his innate sense of doing what he knows is right with whatever biological rationale might enter his mind. Often his reasoning proves biologically unsound, reducing his changes of success and injuring his professional credibility.

A ray of hope has been noted recently through the presentation of a new rationale, one which bolsters valid existing arguments with profound spiritual values. This paper presents a brief history of recent preservation efforts, summarizes the new rationale, and offers the hope that newly defined goals, although lofty, are by no means unattainable.

Acknowledgments

It would be ungrateful of me to prepare a paper on endangered species, especially one involving fishes, without acknowledging the enormous efforts of Professor Carl Hubbs of Scripps Institution of Oceanography and Dr. Robert Rush Miller of the University of Michigan. Many others, agency biologist and academician alike, have made great contributions to the cause, especially in recent years. Special thanks are due Dr. David W. Ehrenfeld of Rutgers University, Dr. Hugh W. Nibley of Brigham Young University, and Mr. Jimmie Durham of the International Indian Treaty Organization, whose works I have referred to and quoted extensively in the preparation of this paper.

Background

My first real involvement with endangered species began in July 1964 during a field trip with Bob Miller and Carl Hubbs in California's Owens Valley. Bob suspected that the Owens pupfish (*Cyprinodon radiosus*) was extinct when he described it (Miller 1948), but he felt it worthwhile to make one final effort

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to locate a remnant population. My interest in endangered and nongame fishes was minimal at that time; yet, when exultant voices resounded through the marsh, a strange feeling came over me. My conversion to the cause of nongame species was instantaneous and dramatic. Fish Slough on the floor of Owens Valley was my Road to Damascus (Miller and Pister 1971), and I have been an active crusader for the past 14 years, almost to the day.

Sympathy for the cause was rare within my agency, and time and funds were virtually unavailable for anything but the management of game species. What work we were able to accomplish was generally done on our own time and expense.

Yet somehow the movement grew. Support was excellent from the academic community; and the Fish and Wildlife Service, which found itself less encumbered by politics and tradition than those of us in state agencies, also offered good assistance, often to cries of anguisH concerning the "Federal Octopus" from within Great Basin state directorships. Sadly, this point of contention still precludes optimum interagency management programming, and we still eagerly await the day when welfare of the resource will overcome agency jurisdiction as the primary point of concern.

The initial meeting of the Desert Fishes Council, formed in desperation in 1969 to stave off the almost certain extinction of several fishes within the Death Valley drainage system, drew 44 individuals, primarily with federal or academic affiliations (Pister 1974). The 1978 Council membership approaches 300 and is growing rapidly as public recognition of the need for desert ecosystem protection increases.

My involvement in endangered species work (and colleagues often state the same motivation) stems from a desire to leave something significant as a mark of my having been here. Somehow, in my advancing career, the idea of providing a bunch of gamefish for people to catch simply was not sufficiently fulfilling. It became apparent to me that if man were ever to exercise his dominion (a term which until recently was disturbingly vague) in an acceptable way, he was going to have to turn a new leaf and face a new set of problems.

Discussion

At a recent symposium on endangered species held at Yale University, Dr. Lee Talbot, vice-president of the International Union for the Conservation of Nature, said that even obscure endangered species can serve as indicators of large environmental problems that may have major adverse effects on people who could not care less about the animal in question. In this context, let us consider the following examples:

Devils Hole

East of Death Valley, Nevada, is a limestone cavern with a tiny pool containing the entire world population of the Devils Hole pupfish (*Cyprinodon diabolis*). Extensive and indiscriminate agricultural development and irrigation in the late 1960s was rapidly lowering the aquifer system supplying the pool, and it was apparent that, unless someone did something to stop it, a full species (the most highly evolved of the Death Valley cyprinodonts) would soon become extinct. This actually was the *cause celebré* which motivated us to form the Desert Fishes Council. We fought long and hard in behalf of Devils Hole and its inhabitants and found, in the process, that the State of Nevada, with the exception of its Department of Fish and Game, was often uncooperative and even antagonistic when asked for assistance in stopping the deadly water table drawdown. This seemed particularly true of the state engineer's office. Nevada is very development oriented and, despite a rather paradoxical state endangered species law, generally viewed as highly undesirable a tiny fish of no economic value which seriously threatened a multimillion dollar ranching operation.

Federal law seemed to offer our only salvation in this matter, so in July 1972 the People of the United States, through the Department of Justice, went to court against the land developer and the State of Nevada as codefendants. Interestingly, the case was not argued on the basis of the Endangered Species Act, but on a point of water law.

Initial judgment was favorable, and after a siege in the appellate court the case was heard (amidst the strong desire of western congressmen to reverse the earlier decisions) by the U.S. Supreme Court. In June 1976 the court ruled unanimously in favor of the People of the United States (and the fish), and we began to regain some confidence in "the system." It was encouraging to know that the Equal Justice under Law inscription over the entrance to the Supreme Court building in Washington, D.C., applies to fish, too.

Probing deeper into the matter, we found that the Ash Meadows ranching operation was only a symptom of a much greater environmental threat. A report by a consultant to the Nevada State Engineer (Nevada State Engineer's Office 1971) to locate and evaluate future water sources for Las Vegas earmarked underground supplies around Devils Hole to provide 3 million acre feet over a 30-year period. At this time, the report indicated, it would no longer be feasible to run the pumps, and the deteriorating quality of what remained would make it unsuitable anyway. However, that 3 million acre feet would allow a sufficient increase in population to facilitate acquisition of water from more permanent sources farther away (such as the Columbia or Snake rivers).

In this case the Devils Hole pupfish proved to be an indicator organism which led, eventually, to a discovery of the underlying politics of the entire matter. Would it be to man's long-term benefit to destroy a spring ecosystem unique in the United States and equaled only in one location in Mexico simply to provide short-term water to a city which must very obviously someday curtail its growth? At least we now have the chance to take a harder look.

Tellico Dam and the Snail Darter

In a related situation, news media throughout the United States have recently been discussing a situation on the Little Tennessee River wherein the tiny snail darter (*Percina tanasi*) has essentially stopped completion of the $116 million Tellico Dam following a 6-3 Supreme Court decision affirming the provisions of the Endangered Species Act of 1973. Reaction by the media has been mixed, with some lauding the decision and others condemning an action that, in their estimation, would waste $116 million simply to save a fish of no known economic value. In the wake of this, Congress (with many members in an election year asking themselves "What if Tellico were in *my* district or state?") is now debating whether or not the Endangered Species Act should even be renewed and, if so, what amendments should be made to "allow greater flexibility."

Again, a look behind the scenes is revealing. First off, TVA (the sponsoring agency) failed to discuss the snail darter problem with the Fish and Wildlife Service until the project was nearly finished, and greatly accelerated the construction schedule to create a stronger case for completing the dam. Secondly, a General Accounting Office study (U.S. General Accounting Office 1977) implemented by Congress revealed a cost-benefit analysis so faulty that even after the expenditure of over $100 million taxpayers would be money ahead if the dam were torn down. In fact, this alternative was offered by TVA Chairman S. David Freeman before a House subcommittee following the Supreme Court decision and release of the General Accounting Office report. Lastly, considering the widespread pressure to terminate or weaken the Endangered Species Act, it is significant to note that in all except one (Tellico) of more than 4,500 consultations between developers and the Fish and Wildlife Service, both the project and the species in question were deemed able to coexist.

Additional Benefits

In addition to the above-listed benefits of revealing the political issues underlying various development proposals, concern over endangered species has resulted in beneficial philosophical shifts within many state fish and wildlife management agencies. Although the primary orientation of such agencies remains one of providing a harvestable product for hunters and anglers, changes are being noted through the implementation of nongame, endangered species, environmental, and land acquisition programs as the future

demands of society become increasingly apparent (Pister 1976).

Costs

What are the direct agency costs of rare and endangered species programs? Small, by most standards. In 1978, according to Fish and Wildlife Service figures, the cost of administering the Endangered Species Act, including aid to the states, was $16.2 million. A figure of $19.4 million is estimated for 1979. It is virtually impossible to accurately assess the dollar costs of delaying a development project during the discussion period with the Fish and Wildlife Service.

A New Rationale

Why do the people of the United States find themselves in the current dilemma? Perhaps Nibley (1978:85–86) says it best: "We have taught our children by precept and example that every living thing exists to be converted into cash, and that whatever would not yield a return should be quickly exterminated to make way for creatures that do." I cannot think of a better way to put it, and I am reminded of Paul's admonition to Timothy nearly 2,000 years ago: "For the love of money is the root of all evil. . . ." (I Tim. 6:10).

In view of the increasing concern of virtually all segments of society over environmental matters generally, and noting this same concern within academic circles, it appears to me highly appropriate that two of the most outstanding essays involving endangered species to emerge during the past decade should be written by eminent scholars representing two very different disciplines. David W. Ehrenfeld, a Harvard M.D. with a Ph.D. in zoology and biochemistry from the University of Florida, is currently professor of biology at Cook College, Rutgers University. Hugh Nibley graduated in history from UCLA and received his Ph.D. from the University of California at Berkeley. Adept in 14 languages, he taught history and languages at the Claremont Colleges in California before moving to Utah. He is now professor of history and religion at Brigham Young University.

Yet, although their academic disciplines may differ, their philosophies blend marvelously well, complement one another, and lead to a logical and acceptable rationale for the preservation of *all* life forms.

Ehrenfeld (1976), in a masterful essay entitled "The Conservation of Non-Resources," does the biologist a great favor by critically analyzing the most popular (and frequently contrived) reasons advanced in defense of a favorite species or program. He defines a resource as a commodity that has an appreciable money value to man and then lists several that do not. These he considers to be non-resources, without conjectural or demonstrated resource value to man. He utilizes the Houston toad (*Bufo houstonensis*) to exemplify this concept and throws fear into the hearts of many zealots when he states quite accurately that certain species may even exhibit a negative value. Ehrenfeld warns against the dangers of prioritizing, or ranking, species or natural areas in a preservation program because of our categorical lack of knowledge about them, be it now or 100 years from now. He feels, further, that formal ranking sets natural area against natural area (and species against species) in an unacceptable and totally unnecessary way, and emphasizes that the need to conserve a particular community or species must be judged independently of the need to conserve anything else (Ehrenfeld 1976:653).

He then goes on (p.654) to state that only one account exists in Western culture of a conservation effort greater than that now taking place, where not a single species was excluded on the basis of low priority, and by all accounts not a single species was lost (Genesis 7:8–9):

> Of clean beasts, and of beasts that are not clean, and of fowls, and of everything that creepeth upon the earth,
> There went in two and two unto Noah into the ark, the male and the female, as God has commanded Noah.

It is encouraging to note that even (or perhaps especially) the more sophisticated writers seem to be rejecting the classical, anthropocentric economic arguments for species preservation in favor of a religious concept presented by Elton (1958) 20 years ago and further developed by Ehrenfeld (1976:654–655), who states:

The non-economic value of communities and species is the simplest of all to state: they should be conserved because they exist and have existed for a long time. Long-standing existence in nature is deemed to carry with it the unimpeachable right to continued existence. Existence is the only criterion of value, and diminution of the number of existing things is the best measure of decrease of value. This is, as mentioned, an ancient way of evaluating "conservability" and by rights ought to be named the "Noah Principle" after the person who was one of the first to put it into practice.

In recent hearings on the Endangered Species Act held by the House Merchant Marine and Fisheries Committee, Jimmie Durham, director of the International Indian Treaty Organization, posed a very logical and pertinent question: Who has the right to destroy a species? Because of Durham's eloquence, any attempt to paraphrase his statements would markedly reduce the feeling which his words convey. The following material has been extracted from his published address (Durham 1978):

In *Ani Yunwiyah*, the language of my people, there is a word for land: *Eloheh*. This same word also means history, culture, and religion. This is because we Cherokees cannot separate our place on the earth from our lives on it, nor from our vision and our meaning as a people. From childhood we are taught that the animals and even the trees and plants that we share a place with are our brothers and sisters.

So when we speak of land, we are not speaking of property, territory or even a piece of ground upon which our houses sit and our crops are grown. We are speaking of something truly sacred.

There is no Cherokee alive who does not remember that Trail of Tears, as we call our march into exile in Oklahoma. There is none among us who does not remember and revere that sacred land, *Echota*.

Today, the Tennessee Valley Authority would like to flood the sacred valley that held our two principal cities, *Echota* and *Tenasi*, after which the state is named. The Tellico project would have destroyed an area of great religious importance, many settlement sites, cemeteries, rich farmlands, forests and the river itself. This is an unneeded dam which can, at the whimsy of TVA, wipe out thousands of years of history of a great and currently oppressed people. To do so would be an insult not only to the Cherokee, but also to all the people in the United States and to humanity. Yes, I am proud enough to state that the history and vision of my people are important to humanity.

The flooding of our valley has been stopped temporarily because of a little fish that lives there and nowhere else. I have seen Atty. Gen. Griffin Bell, the *New York Times* and a national television network make fun of this little fish and I would like to ask why it is considered so humorously insignificant. Because it is little, or because it is a fish?

It is this incredible arrogance towards other life that has caused such destruction in this country. Who is Griffin Bell or the U.S. government to play God and judge the life or death of an entire species of fellow beings which was put here by the same power that put us here? Who has the right to destroy a species of life, and what can assuming that right mean?

Let me be emotional: To me, that fish is not just an abstract "endangered species" although it is that. It is a Cherokee fish and I am its brother. Somehow, it has acted to save my holy land, so I have a strong gratitude for that fish.

The Cherokee people in Tennessee, Oklahoma, the Carolinas, Georgia and wherever we might be are of one voice and of one mind that this dam, this degradation, must be stopped. We want our universe, our *Echota* with all of its fish and all of its life to continue. We are sure that this cannot be against the interests and wishes of the American people.

DEFINITIONS

Although *subdue* and *dominion* as used in Genesis carry a religious connotation, virtually all environmentally oriented discussions in which these words arise seem to end with everyone defining them to suit his own selfish purposes.

We have long been in need of a clear and learned treatise on this subject, and the entire cause of species preservation is fortunate indeed to have someone of Hugh Nibley's stature and capability to provide one for us (Nibley 1978:85–99). His analysis of man's dominion borders on pure genius, and he logically asks in his preface (p.86): "If God were to despise all things beneath him, as we do, where would that leave us?" He then proceeds typically to use a wealth of scripture, classical literature, and other references to develop his theme that "Man's dominion is a call to service, not a license to exterminate" (p.96), and provides an example from a pioneer leader: "while 'subduing the earth' we must be about 'multiplying those organisms of plants and animals God has designed shall dwell upon it,' namely 'all forms of life,' each to multiply in its sphere and element and have joy therein." (p.87). This was indeed an inspired statement from the leader of a group of pioneers seeking to tame a desert wilderness. Nibley suggests an in-depth analysis of the derivation of "dominion," which clearly turns out to be the responsibility of the master for the comfort and well-being of his dependents and guests, "not a predator, a manipulator or an exploiter of other creatures,

but one who cooperates with nature as a diligent husbandman" (p.88).

Nibley continues: "The teaching of Israel laid the heaviest emphasis on responsibility. Since man is quite capable of exercising the awesome powers that have been entrusted to him as the very image of God, he must needs be an example to all, and if he fails in his trust, he can only bring upon himself the condemnation of God and the contempt of all creatures." (pp.89–90).

Nibley's explanation of man's hostility is as logical and obvious as it is painful: "The animal, vegetable, and mineral kingdoms abide the law of their Creator; the whole earth and things pertaining to it, except man, abide the law of their creation, while 'man, who is the offspring of the Gods, will not become subject to the most sensible and self-exalting principles.' (Journal of Discourses, 9:246). With all things going in one direction, men, stubbornly going in the opposite direction, naturally find themselves in the position of one going the wrong way on the freeway during rush hour; the struggle to live becomes a fight *against* nature. Having made himself allergic to almost everything by the Fall, man is given the choice of changing *his* nature so that the animal and vegetable creation will cease to afflict and torment him, or else of waging a truceless war of extermination against all that annoys him until he renders the earth completely uninhabitable." (pp.94–95).

Summary

The obvious benefits of endangered species programs may therefore be summarized as follows:

1. Endangered species generally serve as indicators of larger environmental problems and, when detected, allow analysis and correction of more involved issues during the pursuit of a preservation program.
2. The "Era of Endangered Species" has initiated a process of maturation within state fish and wildlife agencies as they begin to consider *all* species in their program planning, not simply those with an obvious economic value.
3. By preventing the extinction of fish and wildlife species (and *all* life forms), we automatically preserve any anthropocentric values which they may possess, but which research may not yet have discovered.
4. Perhaps the most important reason for preserving endangered species is the realization of the opportunity granted to man—the only species endowed with the capability of truly caring for his fellow creatures—to exercise righteously the dominion granted him by his Creator. Doing so will do much to preserve man's self-respect. The manifestations of this concept can be enormous, including peaceful coexistence with nature, other nations, and himself.

Conclusion

Considering our rather dismal record to date, including threatened changes in the Endangered Species Act resulting from the Tellico Dam-snail darter conflict, the cynic would consider it quite improbable that man would ever categorically accept a religious (or morally based) reason for preserving other life forms. At this point I must assume the role of the optimist and state that a widely accepted nonresource rationale is not only desirable, it is absolutely mandatory if we are ever to gain the necessary political strength to assure adequate recognition of the biota in a proposed development project. It seems unlikely in the foreseeable future that, in terms of dollars, we will ever be able to place a higher value on the Devils Hole pupfish than on a section of resort condominiums in Las Vegas, or prove that the snail darter swimming above Tellico Dam has an economic worth in excess of the electricity produced by the water in which it lives.

Ehrenfeld (1976) states quite correctly that if nonresource arguments are ever to carry their deserved weight, cultural attitudes will have to be changed. This is a big order, but we have no alternative but to try. Henry Ford used to remind his plant managers: "You can say it can be done, or you can say it can't be done and be correct either way."

An analysis of Section 2 (Findings, Purposes, and Policy) of the Endangered Species

Act of 1973 indicates that Congress apparently felt it was worth a try to implement such a cultural change, inasmuch as the states (often the hardest to sell in such matters) and other interested parties are encouraged to develop and maintain conservation programs which meet national and international standards as a key to better safeguarding, for the benefit of all citizens, the nation's heritage in fish and wildlife. Further, the purposes of the act include providing a means whereby the ecosystems upon which endangered and threatened species depend may be conserved. Lastly, the policy of Congress is stated that all federal departments and agencies shall utilize their authorities in furtherance of the act. Although the act lists the physical means of achieving its purposes, it fails to address the matter of enlisting and sustaining philosophical support. Inasmuch as the long-term effectiveness of any legislation is dependent upon its acceptance by the people, it is implicit that the major responsibility for assuring this falls upon those of us who feel strongly about such things.

Reflection

Not long ago I arose early and went for a walk near my Bishop home. I glanced westward and watched the moon set just as the first rays of the rising sun began to tint the great peaks of the Sierra Nevada crest. The effect was spectacularly beautiful and, to me, illustrated the concept of "the beginning and the end." The beginning was represented by an unprecedented degree of enlightenment within the American public and in our own philosophies, and a renewed ability as agencies and individuals to work together toward the management and preservation of all of the nation's (and world's) life forms; the end by a lessening and ultimate cessation of the anthropocentric attitudes within the public and ourselves which have in so many instances "come home to roost" and caused our current dilemma.

The sun continued to rise and the red turn to gold as my thoughts went back to the early days of our desert fish programs. How utterly hopeless everything seemed then! I uttered a silent prayer that the insight, hard work, and example of the earliest workers in this field might inspire us to better serve the multitudes who will come after, and that we might provide them with a legacy reflecting not only our scientific competence, but also our practicality and philosophical maturity; and that this in turn would constitute a crossroads in American thought concerning man's dominion over the earth. and recognizing the absolute truth that the glory of God is intelligence, I ended my prayer with a plea that we might utilize our collective intelligence to glorify Him by exercising a truly righteous dominion equally over His entire creation.

It seems fitting to express here the thoughts of the late anthropologist and humanist Loren Eiseley (1962, preface): "I believe in Christ in every man who dies to contribute to a life beyond his life." He continues: "I have been accused of woollymindedness for entertaining even hope for man. I can only respond that in the dim morning shadows of humanity, the inarticulate creature who first hesitantly formed the words for pity and love must have received similar guffaws around a fire. Yet some men listened, for the words survive."

And the Devils Hole pupfish and snail darter survive, too. Twenty years ago they wouldn't have had a chance.

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ENDANGERED SPECIES ON FEDERAL LANDS

PANEL: PART I, INTRODUCTION

John L. Spinks[1]

Since I've already spoken once during the symposium, I only have two brief points to make for my part of the panel presentation.

One is in terms of public land. The Fish and Wildlife Service has about 35 million acres in the National Wildlife Refuge System. The management of those resources are subject to the same Section 7 scrutiny as any other federal agency action. As a matter of fact, by policy from the director of the Fish and Wildlife Service, it is our responsibility to make certain that we live up to the highest expectations in compliance with Section 7. If there is a finding of either adverse modification of critical habitat or a jeopardy finding, that activity will not be done by the Fish and Wildlife Service—and that is in writing from the director.

The second point I would make is that, though the Fish and Wildlife Service has a lead agency role, as does the National Marine Fisheries Service, in administering the Endangered Species Act of 1973 as amended, I hope all of you here can immediately grasp that the job of protecting endangered and threatened species and recovering these species is completely beyond the scope of any one agency. Were it not for the real dedication and assistance that the service gets from folks like these up here and their agencies, not to mention all the 50 state agencies and the very concerned and dedicated private individuals, we would never get to first base. As a matter of fact, on behalf of the service, I think all we can say is we appreciate the assistance we've gotten over the years—it has been continuous and is still forthcoming—and the interest that generates a symposium like this. We certainly appreciate the attendance of all those here.

PANEL: PART II, FOREST SERVICE PHILOSOPHY OF ENDANGERED SPECIES MANAGEMENT

Jerry P. McIlwain[2]

We have heard some excellent talks on endangered species philosophy here at this session, treating strategies, genetics, ecology, and some new techniques and concepts that are very interesting to me. Within the limitations that are placed on a federal agency, the Forest Service has been dealing with many of these philosophies and strategies for a long time. We have been trying to get them down to the ground level and convert these things that we have all been talking about for the last day and a half into on-the-ground management, and that is basically what I am going to talk to you about today.

I will talk about the Forest Service philosophy of endangered species management and how this policy is being translated into policies and procedures to get the job done, about the overall program to accomplish our endangered species job, land management on the national forest system, and how the research and state and private forestry arms of the Forest Service are affected by the Endangered Species Act.

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The Forest Service has been in the endangered species game for a long time. We set up the Sespe Condor Sanctuary on the Los Padras National Forest in 1946 and had been studying this bird for a considerable number of years before that.

Programs to protect and manage bald eagles, ospreys, Kirtland's warblers, and several others were implemented on national forest system lands long before the Endangered Species Act was passed. Passage of the act in 1973 did give our program considerable impetus and made endangered species management an organic part of our agency responsibilities.

The evaluation of policy and procedures for the management of endangered species is very dynamic at the moment because things are changing so rapidly. Knowledge of the biology of listed species is being acquired rapidly, Congress has recently amended the law, and Fish and Wildlife Service regulations are continually evolving. We have been trying to get a new Forest Service Manual chapter out now for almost three years. It was just about ready to go before the endangered species amendments of this year were passed which did away with some of our policies and procedures, so we are back to the drawing board.

The basic Forest Service philosophy of endangered species management is to meet both the letter and the spirit of the law by achieving the recovery of listed species on national forest lands, not jeopardizing listed species in our other programs, and assuring that Forest Service management does not contribute to a sensitive species qualifying for listing.

The Forest Service moved out rather rapidly in establishing a positive program after the 1973 act was passed. We feel that our programs are going a step further than the requirements of the law in many cases and are establishing a comprehensive endangered species program.

Our program considers not only the federally listed species, but also state-listed species, plus a third category we are calling sensitive species. Sensitive species are those which are proposed to be federally listed or species that are recognized by the Regional Forester to need special management in order to prevent the need for their placement on federal or state lists. All plants that have been officially proposed to be listed are considered sensitive and managed as if they were already listed.

Some interpretations of the law are that the legal requirements exist only as long as a species is listed. If recovery were achieved for that species and it were removed from the list, there would be no more legal protection for that species. The species could then decline to the point that it was relisted and the cycle would begin again. Our programs are aimed at achieving recovery of a listed species and continuing that status in perpetuity.

Endangered species program changes have outstripped the flexibility of our budgeting system. The Forest Service budget is generated at the ground level and aggragated upward. It is also formulated two years ahead of time. The Endangered Species Act Section 7 regulations were just finalized this past January and they impose a considerable number of requirements on the Forest Service and other federal agencies. Of course, our budget was already formulated and was not responsive to the increased work load brought about by the new regulations. Considerable budget adjustments made in the Washington office were necessary. To avoid this happening in the future, it was necessary to prepare two national programs, one for plants and one for animals.

The general thrust of these programs is in three phases: inventory, interim management, and recovery management. These three phases relate to each individual species of concern. We are in phase 1 for a certain group of species, phase 2 for another group, and phase 3 for others.

Basically the first phase is analysis of the situation: identification of research needed, really finding out where we are on a species, and what we need to do. Then we move into the second phase, an interim management phase. This is the actual conducting of needed research relative to habitat requirements, establishing management programs, and protecting the species while we are doing this. The third and final phase is recovery management. This final phase is initiated after recovery plans or other specific Forest

Service plans have been prepared to protect the species. The species and their habitats are managed to achieve recovery and prevent recurrence of endangerment.

Because this is a panel on public land management, we will now turn to some of the specific programs on the national forest system lands.

Of the 236 domestic species currently on the federal list, there are about 70 species that occur on national forest system land. Of these 70, there are quite a few that occur only on Forest Service lands or Forest Service lands play an essential part of the total conservation effort for that species. The 1973 act considerably changed the way we do things in the national forests. The act required us to evaluate all the Forest Service projects, decide whether or not they may affect a species, and, if so, enter into the formal consultation process with the Fish and Wildlife Service. This has been a considerable work load and will certainly grow larger in the future. We have had well over a hundred formal consultations since the regulations became effective in January of this year. Some of them have been very complex. Our field people are involved in several endangered species program activities as a result of national direction from the chief's office.

We have agreed with the Fish and Wildlife Service (as have all federal land managing agencies) to a time frame for making recommendations for the designation of critical habitat for those species already listed and for which no critical habitat was established. This job is in response to the president's request in his environmental message of 1977 that federal agencies speed up identification of critical habitats on public lands.

Our regions have been directed to assure that threatened, endangered, and sensitive species are adequately covered in regional and forest land management plans required by the National Forest Management Act. Guidelines are being developed to determine which management direction should be expressed in regional plans for wide ranging species and which direction should be left up to each individual national forest.

The Forest Service will prepare action plans to accomplish activities identified in recovery plans for our agency. Of course, a recovery plan cannot commit another federal agency to the expenditure of funds. Also, many recovery plans do not provide sufficient details for on-the-ground management activities, so we must go a step further and prepare action plans to further refine those jobs most logical for the Forest Service to accomplish, and to serve as our agreement with the Fish and Wildlife Service to perform certain tasks in the accomplishment of the recovery plan.

We are monitoring, in cooperation with the states, all populations of threatened and endangered species on the national forest.

Another program thrust, which is a legal obligation I have already mentioned, is to review all of our programs and activities and decide whether or not they may affect a listed species. If the project or activities may affect the species, we formally consult with the Fish and Wildlife Service.

The final item related to national direction is to survey listed or sensitive species to locate populations and define habitat characteristics and biological needs.

Before I talk about some specific projects for endangered species, I would like to mention our budget and personnel. As you are aware, the Department of Agriculture gets no appropriations through the Endangered Species Act as does the Department of the Interior and the Department of Commerce. We do have a specific budget item for endangered species that we make up out of our normal wildlife appropriations, and then we have an agreement with Congress about how much money will be spent on the endangered species program. This current fiscal year we are budgeting on the national forest system $5.223 million for endangered species programs. I think that this budget is probably second in size to that of the Fish and Wildlife Service. I am not sure how large the BLM budget is. This sounds like a lot of money, but when you take that much money, allocate it to nine regions, 154 national forest, and umpteen ranger districts, it is not nearly as much as it sounds. In fact, it is not nearly enough to accomplish a proper job.

The Endangered Species Act, along with some other legislation, has really changed our personnel picture also. The Forest Service during the last four or five years has hired an

average of 15 to 20 wildlife biologists a year. This past fiscal year, we hired 123 biologists and much of this increased hiring was a direct result of the Endangered Species Act. I think that upped our total number of wildlife biologists to somewhere in the vicinity of 370 biologists in the national forest system.

The Forest Service is involved in hundreds of projects around the country, but these examples will give you some idea of the type of things that we are getting into, and some of the complexities of the situations that we are dealing with now.

When the California Region began a project to identify and recommend critical habitat for bald eagles, they found that not enough information was available to accomplish the job. We knew the habitat conditions where eagles presently occurred, but information was lacking on the criteria for suitable unoccupied habitat.

We wanted to designate not only the presently occupied habitat, but also unoccupied habitat which was suitable or may be suitable in the foreseeable future. A program was started in northern California to gather the necessary information. A team consisting of a forester and a wildlife biologist evaluated every bald eagle nesting territory in the state, collecting information on such paramaters as size of tree, aspect, distance from water, disturbance factors, productivity of the nest, form of the nest tree, timber types immediately under the nest tree, and timber types out a certain distance from the nest tree. A computer program then analyzed the important factors that went into making up the eagle habitat. This program is just being completed and we are now using the results of the survey to write criteria for the identification of bald eagle habitat. Another project we are doing with eagles is experimentally improving eagle nest trees. Some trees have been pruned to improve them for nesting eagles. We have actually tried to encourage some eagles to move by judicious pruning of trees and, in some cases, by constructing artificial nest platforms in the trees. This is only being done in those areas where the nest tree is dying or is in an area that is subject to a large degree of disturbance.

Another project recently completed in California was the restoration of a peregrine falcon eyrie. An active nest site on the Mendicino National Forest sluffed off of the cliff face. Climbers went up to the original nest ledge and made a pattern. The pattern was then used to preconstruct an artificial nest platform. Crews then drove metal rods into the cliff face, installed the artificial nest platform, and covered it with cement and natural materials to make it look essentially like the natural nest ledge. As far as we know this has not been done before, and we are anxiously waiting to see if the new ledge will be accepted by the peregrines.

Some interesting work on genetic analysis with some of the threatened trout and salamanders is being done. The Little Kern golden trout occurs only in the Little Kern River drainage primarily on the Sequoia National Forest. Over the years, populations of this threatened species have interbred with introduced rainbow stock so that there are now very few pure strain Little Kern golden trout left.

Through the use of the electrophoresis technique, done under contract with the University of California at Davis, it was determined exactly which streams within the watershed contained the pure strain and which streams were genetically polluted, so to speak. With this information, agreement was reached between the California Department of Fish and Game, the National Park Service, and the Forest Service on a management plan for the watershed. This management plan calls for replacement of many of the genetically inferior populations with pure stock, installation of artificial barriers to prevent further interbreeding, and other stream improvement practices.

The electrophoresis technique was also used on the shasta salamander, a species listed as rare by the state of California. This work showed that there were five distinct populations of this salamander, some of which had been genetically isolated for well over 4000 years; these were genetically more different than some of the full species of salamanders were from each other. This brings up new questions of taxonomy and how species should be classified as threatened or endangered and legally protected.

I am going to leave off some of these other

project examples so that we will have more time for questions. The Forest Service research arm is completely separate from the national forest system. It conducts research on any forest and range land, independent of ownership. We have 10 work units or work locations where endangered species work is going on. This covers about 38 different federally listed species.

The state and private forestry program is one which some of you may not know about. This third arm of the Forest Service is involved in providing technical advice on resource management to state foresters and private land owners and administering several federally financed forestry programs. Of course, this program is also subject to the Endangered Species Act. It is very difficult to determine the impact of the act on programs of this type. Both actual and financial assistance and technical assistance given through the state and private forestry program are subject to the act.

The National Forest Management Act is going to drastically change the planning processes of the Forest Service. Very briefly, some of the things that are going to be required by law now are these: we will set wildlife goals and objectives, inventory all species by habitat types, monitor populations and habitat quantity and quality, quantify species and habitat diversity, prescribe protection and management of critical habitats, and formulate and evaluate alternate management regimes. These are things that must be done now by law, and, of course, endangered species management as well as all wildlife management is tied up in these requirements. I will finish with the thought that as we start making forest plans under the new National Forest Management Act, we will most certainly be calling upon you for help.

PANEL: PART III, THE BUREAU OF LAND MANAGEMENT'S ENDANGERED SPECIES PROGRAM

Richard Vernimen[1]

ABSTRACT.— It is the responsibility of the Bureau of Land Management (BLM) to conserve plants and animals . . . and the habitat on which they depend . . . which are officially listed according to federal or state laws in catregories that imply significant potential for extinction. The BLM also provides for the conservation of the habitats of unlisted extinction-prone (i.e., sensitive) plants and animals. It also applies to all BLM programs and actions related to the public lands, the federal subsurface mineral estate, and the submerged lands of the Outer Continental Shelf (OSC).

The BLM administers 448 million acres of land within the 11 western states and Alaska (U.S. Department of the Interior, BLM 1977). In addition, we are responsible for BLM—authorized actions taking place on the Outer Continental Shelf and federally owned subsurface minerals, i.e., coal, oil and gas, etc. (hereinafter all of the above lands will be referred to as BLM-administered lands).

Within these vast acreages and areas of responsibility we must taken into consideration the welfare of 48 threatened and endangered (T/E) animals (U.S. Department of the Interior, BLM 1977) and 3 endangered plants (Federal Reg. 6/20/78). The T/E plants and animals occurring on the subsurface and Outer Continental Shelf (OSC) must also be considered if BLM-initiated actions affect a T/E species or its habitat (i.e., oil and gas impacts on marine mammals). A third category of species we must take into account are state T/E species. Our 1977 statistical report listed 138 species of animals.

With the recent passage of the 1978 amendments to the Endangered Species Act of 1973 (ESA), proposed species must also be considered for formal consultation. A number of plants and animals fall into this category.

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LAND USE

All actions that we allow on BLM-administered lands must be considered for impacts on threatened and endangered species (T/E), i.e., oil and gas leases, land exchanges, grazing permits, pipelines, etc.).

The following figures were used for our fiscal year 1979 and 1980 budget that shows actions requiring Section 7 consultation as per ESA of 1973:

Energy	2500 leases (oil/gas, coal, geothermal)
Timber	Sale of 1.25 billion board feet
Grazing	Issuance of 24,000 use authorizations
Wilderness	Completion of 55 studies
State selections	502,900 acres (excluding Alaska)
Rights-of-way	1700 applications
Mineral leasing (other)	63 million acres private
	290 million acres other federal lands
Other land actions	8,000 cases

The above are cases or actions readily identifiable. Each day we encounter new actions that require review.

LEGISLATION AND AUTHORITY

Authority-Sources

A. *Endangered Species Act of 1973* (16 USC 1531 et seq.) as amended.
B. *Sikes Act, Title II* (16 USC 670 et seq.).
C. *National Environmental Policy Act* (42 USC 4321 et seq.) as amended.
D. *The Federal Land Policy and Management Act of October 21, 1976* (P.L. 94-579).
E. *Department Manual 231.1.1.A.*, General Program Delegation Director, Bureau of Land Management.

The above acts are our basis for developing and carrying out an endangered species program. The major thrust of our program is Section 7 compliance and inventory of habitat.

BLM PROGRAM

Coordination and Liaison, Section 7 Compliance

Section 7 of the ESA of 1973 directs all federal agencies on how to comply with the act. Procedures for this cooperation and consultation can be found in 50 CFR 402 or in the *Federal Register*, volume 43, pages 869–876, 4 January 1978.

The major contact on consultation for BLM is the Fish and Wildlife Service (FWS), but with our administrative responsibilities on the Outer Continental Shelf (OCS) we also consult with the National Marine Fisheries Service of the Department of Commerce. Since many of these OCS cases involve the high seas or foreign countries, we must also contact the State Department. As you can see, the Section 7 process can become exceedingly involved and time consuming.

Because of the mandate placed upon us by Section 7 of the ESA of 1973, major emphasis in work load has been shifted to meet it. Budget increases were added to meet the need. This is a start, but we are working under pressure to meet the demand because of other priorities placed upon us, such as the nation's energy needs.

Critical Habitat Inventory

The president's environmental message of May 1978 requires that the identification and determination of "critical habitats" for endangered species be accelerated.

The secretary of the interior is directing agencies to complete inventories and analyses for the determinations of critical habitats for species on their lands by 1 January 1980.

We have 32 of the known species of animals officially listed on public lands. We have been given increased funds to complete this job. Inventories for some species are fairly simple because their respective habiats are small and centralized. The work begins when we look at species such as the Bald Eagle or the American Peregrine Falcon. Habitats of these species are broad and expansive, requiring many man-hours to complete inventories. Our participation on recovery teams has helped to cut this work load down.

Present Capabilities to Comply with the ESA of 1973

As of 11 November 1978, the BLM has 249 fisheries and wildlife biologists on board. The breakdown by numbers and areas is as follows:

Washington, D.C.	6
Denver Service Center	5
Alaska	9
Arizona	18
California	23
Colorado	22
Eastern States	3
Idaho	22
Montana	26
Nevada	22
New Mexico	15
Oregon	35
Utah	22
Wyoming	18
Outer Continental Shelf	3
Total	249

Within the total 249 biologists, only 2 could be listed as working totally on endangered species, and that is stretching it. We all have other duties as assigned. I myself function as the lead in Washington on nongame species as well as the endangered species liaison officer. Mr. Ken Walker, endangered plant coordinator, will cover the number of botanists we have working on plants.

SUMMARY

Intensified public concern for our environment and the flora and fauna within it has created a demand for all levels of government to engage in active and positive programs to stem the tide of wildlife extinction. We have embarked on an ambitious program to protect and benefit endangered plants and wildlife. Many of our avenues to success are clouded by complex, competitive demands on endangered species habitat by other resource uses and the nation's need for energy. Unraveling ecological complexities to isolate and solve habitat-related problems is not a simple task. Funding and manpower are not available to meet all needs. Despite these difficulties and constraints, we are devoting our best efforts trying to insure that no additional plant or animal become either endangered or extinct on public lands.

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PANEL: PART IV, SUMMARY OF THE ENDANGERED PLANT PROGRAM IN THE BUREAU OF LAND MANAGEMENT

Kenneth G. Walker[1]

I'll explain very briefly our function in the Washington office. You may wonder why there are two of us here from the Bureau of Land Management. The primary reason is, because of the organizational structure at the Washington office, the responsibility for endangered species coordination is in the Division of Wildlife, with Dick Vernimen as the coordinator for the Bureau of Land Management. My function in the Division of Watershed is to assist or carry on the coordinating role for endangered plant species. The sym-

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posium, I feel, has been very enlightening. The scientific community in many instances seems to be at odds as to what really needs to be done for endangered species, what the needs are, and what the protection systems should be. We in the federal agencies do not have many options, although we have our opinions. Our options are limited to the methods for which we follow the dictates of legislation.

Policy for endangered plant species is very similar to that described by the Forest Service. Our prime effort is not only to protect and conserve listed species, but also to carry it a step further and to protect and conserve the proposed species with the idea that if we can manage these species and their habitat the situation will be avoided where they will require official listing. We recently developed a policy for endangered species which I will summarize. It is the policy to protect, conserve, and manage federally and state-listed or proposed listings of sensitive, endangered, or threatened plants and to use its authorities in furtherance of the purposes of the Endangered Species Act and similar state laws. The bureau, through its actions in all planning and management activities, will insure that the actions authorized, funded, or carried out will not jeopardize the continued existence of such species or result in the destruction or modification of the critical habitats. To summarize the policy, as the Forest Service mentioned, our intent is to not only follow the letter of the law, but also the spirit of the law. We have issued several guidelines to our field office to follow this policy. In doing this, we have asked our field office to do two things: first, to add each candidate or listed species which is known or expected to occur within their area of responsibility to a list of these species that will be developed and maintained by our state directors within the area of jurisdiction. The area of responsibility in Utah, for example, would be the entire state, which in turn requires a lot of coordination with the universities, state agencies, private concerns, and others, wherever we can acquire the interest. A second appeal would be for state directors to determine those species which are known or suspected to occur on bureau-administered lands or can reasonably be expected to be influenced by bureau actions. The Bureau of Land Management has the responsibility for management of surface areas, but there also are many areas where we have responsibility for the subsurface minerals management. Coal, in Utah, is an example where we manage the subsurface minerals but, we do not own the surface. This creates many problems.

I will now summarize the program status for the endangered species program in the BLM. I feel almost embarrassed sitting by the Forest Service people when they talk about their funding levels. Our funding for endangered plant species has not been a direct funding effort. We've acquired from other programs approximately $400,000. This includes partial funding of about 40 personnel. Unfortunately, not very many of them are able to spend their full-time in the endangered species effort. We do have a few full-time botanists. The endangered plant program in this bureau is viewed as low priority because of its magnitude. On public lands, only three species have officially been listed. All three of them are in California. We have several hundred proposed species located on public lands. Our endangered plant species program is primarily, at least at this time, as Duane Atwood mentioned this morning, in the inventory stage. We're not yet to the point where we're really able to prepare or do active planning for a particular species or a particular group of species. Our efforts are tied rather closely to our Environmental Statement (ES) Program in the bureau, particularly the range program, which is a magnanimous effort. We have several hundred environmental impact statements to prepare within the next few years. Our endangered species inventory efforts have pretty much centered around ES efforts. Our efforts and methods in conducting these inventories are varied. Some are done in-house by our own people. Many of them we are able to conduct through contracts with universities and others who have such capability.

QUESTIONS TO THE PANEL

Q. The Endangered Species Act is rather narrow about defining this problem. There are quite a few other programs that can be applied. Many of the federal land agencies have natural area programs. There are also a number of wildlife programs that can be brought to bear on the question of peripheral species and their distribution. We have the same problem with plant distribution, so I'm not sure the endangered species program is the right place for that kind of program, depending, of course, on what happens to the whole range. There are a lot of other programs that could help there.

A. That particular problem is one of the things we are trying to address with our sensitive species category in our total endangered species program. We can take species like this and put them on our sensitive species list and then apply land management practices or management practices in a special way. There won't be the legal requirements, but we would treat them for land management purposes the same way we would treat a legally listed species. (McIlwain)

Q. I have a correlary to this I need to address. I don't think it's been addressed to the extent that I need to understand it. Having worked for a private consulting firm, I've often been caught between two grist mills of state species lists and also federal species lists. Specifically, I'd like to know what your plans are for the future. I don't think I understand how you're going to correlate and work out these issues with the states. For example, the Hamper Project is not ad ministered by the state. It's a national environment research park. What if we have a species there that is peripheral and we want to protect it, but the State of Washington doesn't. The population is found in Washington and parts of Oregon, Idaho, and Utah, but in most areas it doesn't warrant or merit consideration as a threatened species. How are you going to handle this conflict with the states? Will you be able to support it?

A. Well, as a matter of fact, I don't see any conflict with the states at all in a situation like this. If a given state has its own endangered species legislation, and if a particular species, be it a peripheral species or whatever, is in trouble in that state, I see nothing wrong with that state listing that species under its legislation as an endangered species and protecting it accordingly. (McIlwain)

Q. By a conflict, I mean to be able to fund them and support them financially. Most of the states don't have an adequate threatened and endangered species program, especially from the standpoint of funding resources. You have infinite amounts compared to what most of them do. Will you be able to support them on the basis of those peripheral populations?

A. We have two separate funding resources in the endangered species program. One is the Section 15 monies, which our general appropriation authorizes, and the other is the Section 6 money, which is dedicated specifically to a grant and aid program through cooperative programs with the states. We have not, as a matter of fact, been able to obligate that money as quickly as we would like to—simply because there has not been enough demand in the states to really get with the program. I don't see any difficulty in funding through a matching 66 percent federal share-33 percent state share for state activities. I don't think we're going to run out of money any time sooner. (Spinks)

Q. Wouldn't those matching funds work only for species that are listed as endangered species under the federal act?

A. No, if they're considering it for listing under the state act. They would also be eligible for funding. (Spinks)

Q. I've enjoyed very much your program, but you have not mentioned the aquatic forms. Now you take the fisheries on the North Atlantic, the whaling. They're vital problems with which we must deal. It seems to me that not only will we have to be financed, but it may even be we'll have to use a little military strength to restrain some of these people who say they have a right to hunt a particular species, the whale and so on. That is a major problem as I see it in connection with the immediate approach in dealing with these species.

A. Your point is well taken. I'm glad the National Marine Fisheries Service is in this act with us. There is basically a division of responsibility in the act between the Departments of Commerce and the Interior, and the oceanic species are under the protection and administrative authority of the National Marine Fisheries Service. Certainly we do not in any way want to diminish the value of those species, as you point out, but that is again the prerogative of the National Marine Fisheries Service; and, as Mr. Vernimen mentioned, the Bureau of Land Management under the OCS leasing program does become involved with the National Marine Fisheries Service in the consultation process, like considering such species as the bow-head whale in Alaska, for instance. (Spinks)

Q. I have a comment on a previous question. The State of Washington is being funded now by endangered species dollars to come up with a list of the state's threatened and endangered species, so it is possible to do that. The state game department is involved in that.

Q. My question to you managers is from the point of view of private industry. I'm a representative of Utah Power and Light Company, and I'm not a biologist. I've learned a lot here in the last couple of days about biology. Obviously, the vital question to us is this. We realize that recent amendments to the act have created a lot of work for you guys to do. Are we going to have to wait for you to get all this work done before we can build any new plants, or will we have to provide some of the funding to get some work done on a specific basis by ourselves?

A. No, you do not, as a matter of fact, have to wait until there are new Section 7 regulations promulgated, which could take some time. We are proceeding with the consultation process under the existing Section 7 regulations which Jerry McIlwain alluded to as having been published in January 1978. The

world is not going to stop until we have the new regulations. (Spinks)

Q. I want to ask a question concerning the program of the Forest Service people and the BLM in terms of the protective habitat, just to clarify what I'm concerned with. For a number of years I cooperated with some of the folks from California who were trying to preserve some sand dunes in southeastern California, southern Nevada, and perhaps other areas from dune buggies and off-road vehicles that just traversed the area without any concern for the animals or the plants that were there. Now I haven't heard from Bob Stebbins or Dave Wake or some of those folks for a few years as to whether or not they have succeeded in convincing the Bureau of Land Management that some steps should be taken to protect those sand dunes habitats before the sand adapted and a number of other forms are exclusively restricted to those areas. What has been done and what is the program of the Bureau now to protect habitat from these kinds of degradations?

A. We do now have the three species in California that are officially listed. I believe two of them are in the sand dunes area. For one of them, specifically, the Eureka Sand Dune Grass, the Bureau of Land Management has tried to close this area. We've received some criticism as to how effective the closure of these lands has been. Others say it's been very effective. But, to go back to the other part of my answer, our planning process is to go through our inventories and identify critical habitats, sensitive species, proposed species with their habitats, and, through the planning process, tie these areas in with other proposed actions, one of which could be off-road vehicle use. Then, in the final recommendations through our planning process, the decision is made then as to what action will be taken in regards to that area—whether it be closure, restrictions from other uses, grazing, off-road vehicles, or other means to protect certain species. This is the process. Now the actual implications of success to this process we've yet to see in many cases, but we are making a sincere attempt. (Walker)

I think the other area we can talk about, speaking of California, is the Desert Tortoise area, on which Dr. Kristine Berry and a team of other people have been working. We have fenced out most of that area. We have also posted signs, although I have heard recently that 400 signs have disappeared. We also have off-road vehicle regulations we are looking at, where we would close it to such vehicles. Incidentally, one of the beetles proposed does occur right in the middle of an off-road vehicle area in Nevada.

We also have authority for emergency closures if we want to use it. (Vernimen)

Q. What I'm trying to suggest is that if the Bureau of Land Management or private industries, do not protect the desert habitat, we stand to lose a lot of this very valuable material.

Q. I'd like to bring up the controversy of reintroduction in an area of historic range, but not now present. We ran into it with the Colorado squawfish. I was wondering if the land management people would comment about taking an endangered species into a recovery plan, trying to get it off the list more or less by reintroduction into the historic range. Do you run into the resistance of a local forester or a local district manager saying, "If I have to worry about that I won't be able to go into the campground"?

A. That's a very difficult and subjective question, one which is extremely hard to formulate a policy on because you have to adjust to the situation on something like that. Certainly we're not going to reintroduce grizzlies to the plains where they once occurred around the Denver area. That's completely unreasonable. On the other hand, in the process of identifying the essential habitats or the legally designated critical habitats on the public lands, we found a lot of these that are historical into which we can logically expand species. Somewhere in the middle between the unreasonable and the feasible is the line, and how you define that line is very difficult. It's going to be a subjective decision. (McIlwain)

I'd like to cite an example. In Arizona they want to reintroduce the woundfin into historical habitat. At the same time, this habitat is the number one geothermal exploration area in Arizona. This is the type of administrative problem we get into, and I am to the point now where I tend to agree with a state director who says, "No, not until further studies are completed." The problem is "Can we under the act say no?" So, right now that opinion is in the solicitor's office. These are the kinds of things you run into. You've got to use some judgement. We have an area that's being managed for some specific resource and then all of a sudden we throw something else in there that is going to change it. We're going to have to weigh that very heavily before we reintroduce it. (Vernimen)

I'd like to make one more comment before we beat this question to death. Is this a situation where it is really necessary for the survival of the species, or is it something we would like to see for the promulgation of the species? To me this is the big question, and it gets down to whether we really need to or just want to. I think reintroduction of a species should be considered as a last resort in the perpetuation of the species. We have to consider the problems we run into with reintroduction. Are we creating more problems than we are solving?

Q. In Utah we have watched the systematic destruction of the Lynndyl Sand Dune area, the Coral Pink Sand Dune area, and the Hurricane Sand Dune area, all of these under major control of the Bureau of Land Management. I am about to describe a new species of sunflower from the Lynndyl Sand Dunes, known in Utah by the misnomer, Little Sahara. It is not. It cannot be. It is systematically being destroyed. We're not talking about reintroducing something, but we're talking about protecting something the Lynndyl Sand Dunes have, among other unique species which Professor Stutz mentioned earlier today. The Coral Pink Dunes have still others. The ones at Hurricane are unexplored. We don't know what's on them. We may never be able to find out because of off-road vehicle use. What is the potential then, for a turnabout for at least a part of these areas?

A. It just so happens that when I was in the Richfield district, as well as being a wildlife biologist I was a recreation specialist and I did have something to do with Little Sahara as you call it. I am not too familiar with the Hurricane area you talk about. Now the southern part of the Coral Pink Sand Dunes—correct me if I'm wrong—are managed by the state as a state park. My question is "Have you contacted the state office here and informed the Bureau of Land Management that you have found those plants?" (Vernimen)

Q. How does the BLM treat endangered or threatened species on subsurface land? By that we mean private ownership of the surface and someone else owns the minerals, oil, gas, coal, etc.

A. First of all, the identification of the critical habitat and the inventories (unless we have an action taking place right at that time) is the responsibility of the Fish and Wildlife Service on the private lands. If you take the case of the Red Cockaded Woodpecker in Alabama, where the BLM has some subsurface coal, the BLM is doing the inventories. The BLM is also doing the inventories on the Eastern Cougar. We are in the process of contracting an individual to do the inventories on that. If we would let a lease go, we are initiating an action. We are responsible to see that that species is protected.

Q. Is that also the case for critical habitat on state land for endangered plants and endangered plants on private lands?

A. Are you saying designation of a critical habitat or protection of a critical habitat? (Vernimen)

Q. Identifying of an endangered plant on private surface land but federal subsurface. Wouldn't the private landowner have the discretion of saving that plant?

A. Well, no. If we didn't sell the coal in there, it wouldn't be mined. (Vernimen)

Q. So you could deny the lease of such materials?

A. That's correct. (Vernimen)

A. May I address a couple of things that you said. Number one, plants are not protected from being taken under the act. If the private landowner has a bunch of furbish louseworts or whatever and the man wants to go out there and chop them all down with a hoe, that's legal. The second point is that, in terms of having something protected by virtue of having critical habitat determined for it, it is protected from a federal action under Section 7, whether or not there is any critical habitat there. There is a basic question of jeopardy. Among other things in Section 7, besides almost an affirmative action clause for federal agencies to do some good things for listed species, there is the no section that says they shall insure their actions do not jeopardize the continued existence of a species. So, with or without critical habitat designation, there would still be this responsibility to not jeopardize the species. (Spinks)

Q. You said yesterday, when you were ennumerating the amendments to the act, that the application for critical habitat would be withdrawn.

A. Our understanding at this point in time is that the outstanding proposals for critical habitat designation will be withdrawn and reproposed to bring them in compliance with the 1978 amendments. (Spinks)

Q. In response to that, I'd like to ask Mr. McIlwain what kind of protection will be given to the critical habitats of the grizzly bear, mainly because there is such a controversy over how much should be given them?

A. As far as I'm concerned, critical habitat on forest service lands doesn't really mean very much because we're protecting that critter or the habitat of that listed species as a requirement of the law regardless of whether it is legally designated as critical habitat or not. We have management programs established now to protect grizzly bear habitat and we're establishing others as time goes on. It really makes little difference whether critical habitat is legally designated or not for the time being. (McIlwain)

Q. I'd like a little clarification with regard to the conflict between the Endangered Species Act and mining development. There seems to be a rather nebulous area.

A. I know just what you're talking about. I have several memos in my office about people asking just where does the 1872 Mining Law and the Endangered Species Act fit in. As you know, they are both nondiscretionary, and it's kind of like two penalties on a football field. They more or less nullify one another. I'm not at liberty to comment right now. The solicitor is coming out with an opinion on the 1872 Mining Law and the Endangered Species Act, and I don't know yet what he is going to say. Right now they can go ahead with exploration and mining development for hardrock minerals, gold, silver, and so forth. There is nothing that the Endangered Species Act can do to stop them. Nothing. (Vernimem)

My only comment is that we may be finding out what happens in this regard before too long because we have two situations now on Forest Service land, two similar conflicts, one in Arizona and one in California, conflicts between the Mining Act of 1872 and the Endangered Species Act in relation to an application for mining within a bald eagle nesting territory. Either or both of those may get to court before too long. (McIlwain)

Q. Would the Forest Service get a different opinion if you went through a different group as it were?

A. Well, we go through a different solicitor. We go through the USDA Office of the General Council, which is the same as a solicitor. (McIlwain)

Q. Are you seeking an opinion also?

A. No, we're not. (McIlwain)

The bottom line here on the opinion of a solicitor or the Office of General Council from the Department of Agriculture, as in the case of the U.S. Forest Service, is an internal guidance mechanism for that department or agency. The real bottom line is written through the development of case law, and, until there is sufficient litigation involving such conflicts as mining and the Endangered Species Act, there will not be a hard and fast answer to that very good question. (Spinks)

Q. Your statement puzzles me a little bit regarding conflict between the Endangered Species Act and the mining law with respect to bald eagles, especially the protection of bald eagles is so stringent with regards to nesting areas, etc. Isn't the Forest Service required to adhere to that?

A. Yes, we're required to adhere to that, but there is a question as to when you are really harrassing a bird. In the particular conflicts that I'm talking about, we have established a territory for a bald eagle nesting pair, and the mining people want to build a road through that territory and mine outside of it. We've told them no. We're set up to be sued any way we go. If we give a permit to the mining operation, we're going to be sued by the environmentalists under the bald eagle act or the Endangered Species Act or others. On the other hand, if we say no, we'll be sued by the mining interests. In this particular case we decided to remain on the side of the environmentalists. (McIlwain)

Q. The Fish and Wildlife Service just recently issued a proposal for critical habitat for the squawfish. Will you finalize that rule making, or are you still working that thing over? What is that status.

A. Like other proposed rule makings for critical habitat determination, that will have to be reproposed to comply with the 1978 act amendments.

Q. It will be reproposed then at some future date?

A. Yes it will. (Spinks)

AUTHOR AND TITLE INDEX FOR THE ENDANGERED SPECIES: A SYMPOSIUM

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